INCOMMANDS TDP

Human Factors Evaluation of the Command Decision Support Capability Prototype

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Abstract

The Innovative Naval COMbat MANagement Decision Support (INCOMMANDS) Technology Demonstration Project (TDP) attempts to improve the performance of Threat Evaluation (TE) and Combat Power Management (CPM) functions in response to multiple threats and impediments introduced by the littoral environment. Specifically, the purpose of the INCOMMANDS TDP is to develop and demonstrate advanced Above Water Warfare (AWW) command decision support concepts for the command team of the Halifax Class Frigate in order to improve the overall TE and CPM decision-making effectiveness. This report presents preliminary validation results stemming from a Heuristic Evaluation by a Human Factors analyst and Usability and Utility Testing with Naval operators of the INCOMMANDS Command Decision Support Capability (CDSC) prototype. The results of the usability and utility evaluation suggest that the concepts presented in the INCOMMANDS CDSC would improve task performance, increase situation awareness, and decrease operator workload. Further analysis and evaluation efforts are required to substantiate this finding.

Résumé

Le projet de démonstration technologique (PDT) INCOMMANDS (Innovative Naval COMbat MANagement Decision Support, en anglais) vise à améliorer l'efficacité des fonctions d'évaluation des menaces et de gestion de la puissance de combat dans le cadre de scénarios de menaces multiples et d'obstacles introduits par le milieu littoral. Plus précisément, le PDT INCOMMANDS vise à élaborer et à démontrer des concepts avancés d'aide aux prises de décisions de commandement en situation de guerre aérienne et de surface pour l'équipe de commandement des frégates de classe Halifax afin d'améliorer ses capacités d'évaluation de la menace et de gestion de la puissance de combat. Le présent rapport expose les résultats de validation préliminaire d'une évaluation heuristique par un analyste des facteurs humains et d'une série d'essais de convivialité et de fonctionnalité effectués avec des opérateurs navals du prototype d'aide à la décision de commandement développé dans le cadre du projet INCOMMANDS. Les résultats de cette évaluation suggèrent que les concepts mis de l'avant par le PDT INCOMMANDS permettraient d'améliorer l'accomplissement des tâches, d'augmenter la connaissance de la situation et de réduire la charge de travail des opérateurs. D'autres analyses et évaluations seront nécessaires pour confirmer ces constatations.

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Executive summary

INCOMMANDS TDP: Human Factors Evaluation of the Command Decision Support Capability Prototype

Introduction or background: The Innovative Naval COMbat MANagement Decision Support (INCOMMANDS) Technology Demonstration Project (TDP) attempts to improve the performance of Threat Evaluation (TE) and Combat Power Management (CPM) functions in response to multiple threats and impediments introduced by the littoral environment. Specifically, the purpose of the INCOMMANDS TDP is to develop and demonstrate advanced Above Water Warfare (AWW) command decision support concepts for the command team of the Halifax Class Frigate in order to improve the overall decision-making effectiveness for TE and CPM

This report describes results stemming from:

1. A Heuristic Evaluation verifying compliance of the INCOMMANDS Command Decision Support Capability (CDSC) design with guidelines and principles stipulated in the INCOMMANDS TDP Human Factors Design and Evaluation Guide.

2. Usability and Utility Testing of the INCOMMANDS CDSC prototype with Naval operators in order to rate the usability of the system, their comfort level when using the system, their overall workload and situation awareness when using the system, and their overall satisfaction with the system.

Results & Significance: Based on the evaluation of the INCOMMANDS CDSC, it was concluded that:

1. Both evaluation techniques provide complementary insight into improving the INCOMMANDS CDSC. The Heuristic Evaluation helps to ensure that the design of system is compliant with HCI best practices. Whereas the Usability and Utility Testing with Naval operators ensures that contextual feedback is obtained which is lacking from the former evaluation technique.

2. The results from the Heuristic Evaluation provide specific direction to support future development of the INCOMMANDS CDSC in order to improve the overall usability of the system. As such, any additional work to be completed on the system should attempt to improve the usability of the system by both fixing the identified non-compliances as well as adding the missing functionality.

3. Based on the participant feedback received during the Usability and Utility Testing, the following preliminary conclusions can be postulated (additional studies are recommended to further validate these claims):

a. The proposed INCOMMANDS CDSC OMI concepts are in line with the current operational requirements of the Operations Room Officer (ORO) and Sensor Weapons Controller (SWC) Naval operators and would make their job easier.

b. The participants positively rated ease of use of the system, their comfort level when using the system, their understanding of what the system was doing at all times, and overall satisfaction with the system.

c. Overall workload would decrease when using the INCOMMANDS CDSC compared to using only the physical display for TE and CPM activities. Furthermore, overall workload would decrease in a high workload situation relative to a low workload situation.

d. Overall situation awareness would improve when using the INCOMMANDS CDSC compared to using only the physical display. Overall situation awareness would increase in a high workload situation compared to a low workload situation.

e. The INCOMMANDS CDSC can be employed in situations subject to time pressure.

f. The INCOMMANDS CDSC would not interfere with the flow of communications in the operations room.

Future plans: Further analysis and evaluation efforts are required to substantiate the findings from the usability and utility trial. Future evaluations should include the collection of objective performance measures using the experimental plan outlined in Annex F. As well, a follow-up heuristic evaluation should be conducted if the CDSC is fully implemented to confirm compliance with the INCOMMANDS TDP Human Factors Design and Evaluation Guide.

Sommaire

INCOMMANDS TDP: Human Factors Evaluation of the Command Decision Support Capability Prototype

Kevin Baker and Lisa Hagen; DRDC Toronto CR 2009-041; Defence R&D Canada – Toronto; March 2009.

Introduction ou contexte: Le projet de démonstration technologique (PDT) INCOMMANDS (Innovative Naval COMbat MANagement Decision Support, en anglais) vise à améliorer l'efficacité des fonctions d'évaluation des menaces et de gestion de la puissance de combat dans le cadre de scénarios de menaces multiples et d'obstacles introduits par le milieu littoral. Plus précisément, le PDT INCOMMANDS vise à élaborer et à démontrer des concepts avancés d'aide aux prises de décisions de commandement en situation de guerre aérienne et de surface pour l'équipe de commandement des frégates de classe Halifax afin d'améliorer ses capacités d'évaluation de la menace et de gestion de la puissance de combat.

Le présent rapport décrit les résultats des projets suivants :

1. Évaluation heuristique visant à vérifier le degré de conformité de la conception de capacité d'aide aux décisions de commandement avec les lignes directrices et les principes énoncés dans le Guide de conception et d'évaluation des facteurs humains du PDT INCOMMANDS.

2. Essais de convivialité et de fonctionnalité du prototype CDSC INCOMMANDS entre les mains d'opérateurs navals dans le but d'évaluer la facilité d'utilisation perçue, le degré de confort, la charge de travail globale et la connaissance de la situation par les opérateurs, ainsi que leur degré de satisfaction générale à l'égard de ce système.

Résultats et conséquences: Il ressort de cette évaluation du prototype CDSC INCOMMANDS que:

1. Les deux techniques d'évaluation fournissent des perspectives complémentaires d'amélioration de la CDSC INCOMMANDS. L'évaluation heuristique permet de s'assurer que la conception du système est conforme aux pratiques recommandées en matière d'interfaces homme-machine. Pour ce qui est des essais de convivialité et de fonctionnalité avec des opérateurs navals, ils fournissent les réactions humaines en contexte qui manquent dans l'autre technique d'évaluation.

2. Les résultats de l'évaluation heuristique fournissent des indications spécifiques pour l'orientation des futurs développements de la CADC INCOMMANDS en vue d'améliorer la convivialité du système. Dans cet esprit, tous les travaux futurs à effectuer sur le système devront viser à améliorer sa convivialité en corrigeant les non-conformités identifiées, en plus d'incorporer les fonctionnalités manquantes.

3. Les commentaires des participants aux essais permettent de tirer les conclusions préliminaires suivantes (qui devraient cependant être validées par des études complémentaires) :

a. Les concepts d'interface opérateur-système proposés pour la CDSC INCOMMANDS conviennent aux exigences opérationnelles actuelles des opérateurs navals OSO et SWC et vont dans le sens de l'allègement de leur charge de travail.

b. Les participants ont jugé favorablement la facilité d'utilisation, se sont sentis à l'aise lorsqu'ils ont travaillé avec le système, ont eu un bon niveau de compréhension de son fonctionnement et se sont déclaré globalement satisfaits.

c. L'utilisation de la CDSC INCOMMANDS permettra de réduire la charge de travail globale par rapport à l'utilisation des affichages physiques seuls pour les activités de TE et de CPM. De plus, le système devrait permettre de réduire la charge de travail dans une situation à haute intensité comparativement à une situation de faible intensité.

d. L'utilisation de la CDSC INCOMMANDS permettra d'assurer un meilleur éveil situationnel, toujours par rapport aux affichages physiques seuls. L'éveil situationnel global serait amélioré dans une situation à haute intensité comparativement à une situation de faible intensité.

e. La CDSC INCOMMANDS peut être employée dans des situations impliquant des contraintes de temps critiques.

f. La CADC INCOMMANDS n'a pas d'incidence négative sur les communications qui se déroulent dans la salle des opérations.

Plans pour l'avenir: Il faudra prévoir d'autres efforts d'analyse et d'évaluation pour confirmer les enseignements tirés des essais de convivialité et de fonctionnalité. Ces évaluations futures devraient prévoir la collecte de mesures de performance objectives, comme prévu dans le plan expérimental exposé dans Annex F. Enfin, si la CDSC est complètement implantée, il faudra prévoir une évaluation heuristique afin de confirmer le degré de conformité avec le Guide de conception et d'évaluation des facteurs humains du PDT INCOMMANDS.

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1   Introduction

1.1   Background

Operations by the HALIFAX Class frigates expose the ship to an array of risks that require the identification and prioritization of threats and, if required, the application of combat power resources to counter the threat's intent to inflict harm. Currently, these functions are performed by a select number of individual in the operations room via a series of cognitive processes. While the operators are reasonably adept at performing these functions for a single threat, their ability to effectively achieve similar results for a multi-threat, multi-axis threat is severely hampered. Furthermore, the HALIFAX Class ships are increasingly required to conduct operations in a littoral environment, an operational environment characterized by high density small craft traffic, land-based threats, impeding meteorological conditions, and difficult terrain for naval operations. This cluttered littoral environment provides an operational environment that is conducive to attacks from asymmetric threats such as suicide attack by a small boat or swarms of small boats carrying heavy or small arms, low and slow flyers, and a wide range of underwater mines. In turn, this provides a new set of challenges for the Canadian Navy as the time and space for a ship to detect and react to the threats is effectively reduced.

The Innovative Naval COMbat MANagement Decision Support (INCOMMANDS) Technology Demonstration Project (TDP) attempts to improve the performance of Threat Evaluation (TE) and Combat Power Management (CPM) functions in response to multiple threats and impediments introduced by the littoral environment. Specifically, the purpose of the INCOMMANDS TDP is to develop and demonstrate advanced Above Water Warfare (AWW) command decision support concepts for the command team of the Halifax Class Frigate in order to improve the overall TE and CPM decision-making effectiveness.

Specific objectives of the TDP are to:

1. develop and demonstrate advanced AWW command decision support concepts in a manner that will assist the Halifax Class Modernization (HCM)/FELEX project define specifications for TE and CPM functions that are practicable for Canadian industry,

2. elicit the Canadian Navy's cognitive/decision support and information requirements to perform single ship AWW command and control,

3. develop a flexible and robust software architecture that enables the integration of heterogeneous algorithms and incremental enhancements,

4. develop a knowledge-based framework that allows the efficient exploitation of *a priori* information and improves both human and automated TE and CPM functions,

5. develop comprehensive evaluation methods and metrics (measures of performance (MOPs) and measures of effectiveness (MOEs)) that permit the empirical validation and assessment of new decision support systems and human decision-making effectiveness,

6. develop an advanced naval command and control (C2) modeling and simulation capability that will be compatible with and of interest to the Canadian Forces Maritime Warfare Centre (CFMWC), and

7. explore multi-ship CPM concepts in order to support the Canadian Navy's contribution to the international Battle Management Command, Control, Communications, Computers, and Intelligence (BMC4I) project through a Task Group conceptual study.

1.2   Objective

In support of objective 2 of the INCOMMANDS TDP, CAE PS elicited information from Canadian Navy Subject Matter Experts (SMEs) regarding the conduct of C2 functions on-board the HALIFAX Class frigate. Results of this effort are presented in the INCOMMANDS System Analysis Report [5]. Further to this initial system analysis effort, a concept of operation and preliminary OMI design concepts for the INCOMMANDS Command Decision Support Concept (CDSC) were developed in accordance with objective 1 of the INCOMMANDS TDP. These results are presented in the INCOMMANDS TDP: OMI Design Concepts report [3].

As a follow on to these efforts, the following report documents the findings stemming from an evaluation of the INCOMMANDS CDSC OMI. The purpose of the present investigation was to:

1. Perform a heuristic evaluation of the INCOMMANDS CDSC to insure that specific elements of its design are compliant with the INCOMMANDS TDP: Human Factors Design and Evaluation Guide [2], and

2. Collect utility and usability data to be used in the development, validation and implementation of decision support concepts to support the conduct of threat evaluation and application of combat power functions by Canadian Forces (CF) personnel on-board a HALIFAX Class frigate.

Originally, the purpose of the study was to conduct a laboratory-based experiment requiring participants to perform activities and make decisions to support goals pertaining to threat evaluation and management of combat power. Situational awareness, workload, task performance and usability data were to be collected during the experiment (Annex F); however, the current INCOMMANDS prototype was not able to support the experimental demands due in part to time budget, and SME availability constraints. Therefore, the evaluation was limited to Usability and a Utility Testing to assess the system's functionality, judge the effect of the interface on the user, and identify usability and utility problems.

1.3   This Document

This document describes the usability and utility trial methodology, the plan for conducting the Human Factors (HF) evaluation of the INCOMMANDS CDSC, the results of these subjective evaluations, and recommendations for future work. The report consists of the following sections:

1. Section One provides background information and the objectives of the trial;

2. Section Two provides background details regarding Naval C2 functions and INCOMMANDS CDSC;

3. Section Three outlines the evaluation methodology utilized for the INCOMMANDS TDP as well as the process for both the Heuristic Evaluation and Usability and Utility Testing;

4. Section Four summarized the results stemming from the Heuristic Evaluation;

5. Section Five presents the results of the Usability and Utility Testing of the INCOMMANDS CDSC;

6. Section Six details overall conclusions in regards to the conduct of the overall evaluation of the system.

7. Annex A provides the compliance matrix that captures the results from the Heuristic Evaluation of the INCOMMANDS CDSC;

8. Annex B presents the participant Informed Consent Form for the Usability and Utility Testing;

9. Annex C provides the Threat Evaluation Usability Questionnaire for the Usability and Utility Testing;

10. Annex D presents the Combat Power Management Usability Questionnaire for the Usability and Utility Testing;

11. Annex E presents the Overall Utility Questionnaire for the Usability and Utility Testing; and

12. Annex F provides a future experimental plan including informed consent and experimental questionnaires.

2   Background

2.1   General

As background to the conduct of both the Heuristic Evaluation and Usability and Utility Testing, the following sections provide a high level overview of the concepts surrounding Naval C2 functions and the INCOMMANDS CDSC.

2.2   Naval C2 Functions

The fundamental objective of the project is focus on the conduct of TE and CPM functions, primarily by the Operations Room Officer (ORO) and Sensor Weapons Controller (SWC) onboard the HALIFAX Class frigate, as it pertains to AWW. As depicted in Figure 1, the naval C2 process can be decomposed into a set of generally accepted functions that must be executed within some reasonable delays to ensure mission success [10]. These functions include: Picture Compilation; Threat Evaluation; Engageability Assessment; and Combat Power Management.
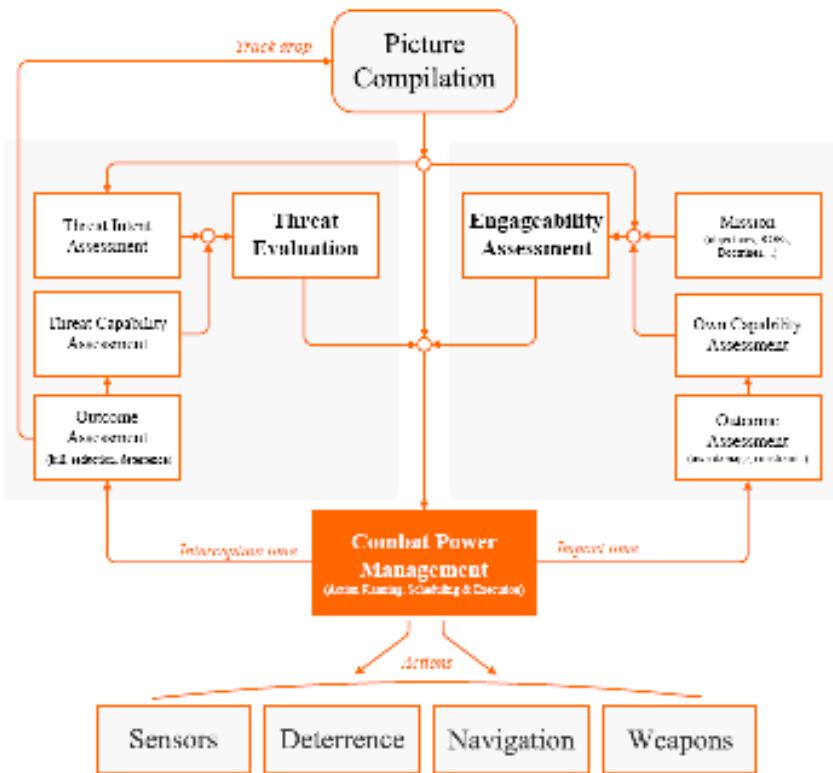
Figure 1: Naval C2 Process [10]

While the picture compilation function is an essential prerequisite for supporting the performance of the remaining three functions, it was not the focus of the INCOMMANDS TDP. It has been

included in this section for completeness. A high-level description of those functions, related to battlespace management, is given in the following subsections. The intent is to introduce these concepts while focusing on the conduct of these functions within the context of a single platform and multi-platform scenarios in subsequent sections.

2.3 Picture Compilation

In all maritime operations, ranging from peacetime through wartime, a fundamental requirement is the compilation of a plot of surface, air, and subsurface tracks. The process of all actions and activities aimed at compiling a plot is referred to as picture compilation. In maritime operations, picture compilation will normally be executed to support decision making in relation to the mission. The nature of the mission will dictate the importance of the plot and what information is to be derived from it.

Picture compilation involves the following sub-processes [11] as represented in Figure 2 [10]:

1. **Object Detection** includes the employment of sensors in a volume of interest in order to determine the presence or absence of objects or object-related data;

2. **Localization** (or Object Tracking) includes the employment of sensors to determine the positional information and movements of an object; and

3. **Object Recognition** includes the employment of sensors to determine characteristics of an object. Comparing the collected characteristics against reference (or *a priori*) data can lead to correlation with a level of confidence. **Object Identification** includes the assignment of one of the six standard identities to a detected contact (hostile, suspect, unknown, neutral, assumed friend, friend).

Sensors available for picture compilation include those organic to a particular platform (e.g., radar, electro-optical (EO), electronic support measures (ESM), acoustics) as well as assets that are assigned as direct support (e.g., submarines, marine patrol aircraft). Data links, voice communications, and messages are used to transfer object information between two or more platforms during task group or coalition operations.

2.4 Threat Evaluation

Threat evaluation establishes the current intent and capabilities of non-friendly entities within the volume of interest based on *a priori* information, the tactical picture (and track database), available intelligence, constraints, and data received from complementary sources in relation to the mission objectives (Figure 3). It is an ongoing process of determining if an entity intends (i.e., threat intent) and is able to (i.e., threat capability) inflict evil, injury, or damage to the defending forces and/or their interests, along with the prioritized ranking of such entities according to the level of threat they pose to ownship [1]. This output is intended to support the determination of the ability of the ownship to engage a specific threat.
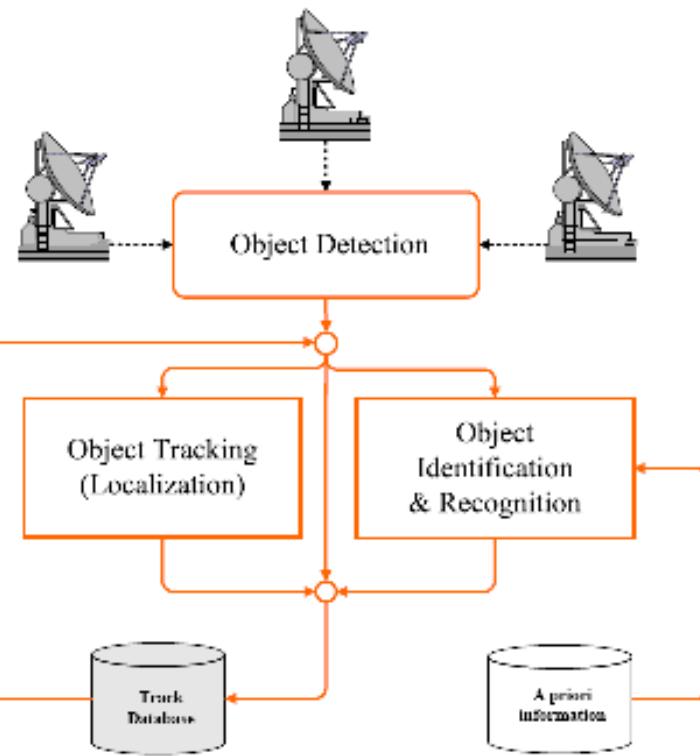
Figure 2: Picture Compilation [10]
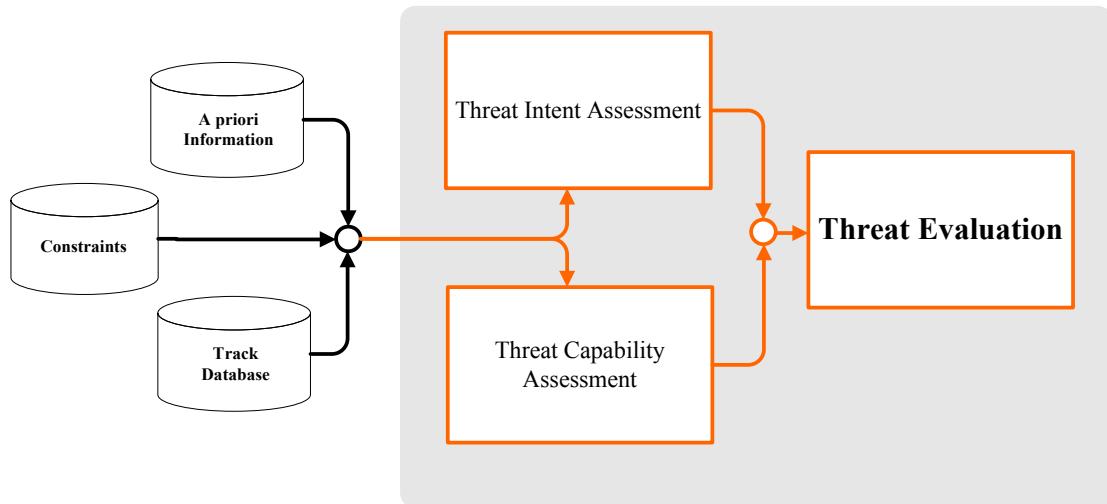
Figure 3: Threat Evaluation [10]

Collated information from all available sources is interpreted as part of the overall analysis of threat information in an attempt to discern patterns which may provide clues as to the:

1. **Intent of the threat.** This is a determination of whether the threat is displaying hostile intent (or not) with respect to a target. Hostile intent translates into the will or determination of a threat to inflict harm or injury [1].

2. **Capability of the threat.** This is a determination of the capability of a live track and involves evaluating both its opportunity and lethality. Opportunity involves evaluating if and when the threat has the ability to attack its target. Lethality is static information regarding the level of damage a threat can deliver if its combat power is applied against a target. The threat will only have the opportunity to deliver its lethality provided the following conditions are satisfied: the threat has sufficient energy to reach the target, the threat can detect and track the target, and physical obstructions do not impede access to the target [1].

A suite of radar, ESM, and acoustic analysis and interpretation tools may also be at the operator's disposal to assist in the performance of this task.

2.5   Engageability Assessment

Within the volume of interest, operators will evaluate the feasibility of own force's engagement options against the non-friendly entities (Figure 4). This process is intended to assist the application of combat power by eliminating candidate solutions that violate one or more hard constraints and therefore are not feasible for execution [10].

This process takes into account a series of inputs of the following nature [10]:

1. **Mission Restraints.** Impacts mission constraints on combat power (CP) deployment including rules of engagement (ROE); mission objectives; other warfare in progress or planned; and tactical doctrine based on a priori mission planning; and

2. **Own Capability Assessment.** This involves the estimation of the performance of combat power resources against individual threats. This requires the evaluation of the following two primary factors:

   a. Determination of the readiness of own combat power which is achieved through the evaluation of: availability of combat power (e.g., current combat power inventory, assignment status, readiness of support resources, and damage to combat power resources), and the reliability of combat power resources (e.g., mean time between failures). This assessment is completed independent of the threat.

   b. Performance prediction of combat resources which is dependent on the reliability of combat power resources, damage to combat power deployment systems, performance of combat power resource (e.g., lethality, probability of success, time constraints etc.), and, impact of environmental constraints (e.g., physical obstructions, electronic attack, weather conditions, sea state etc.) on CP deployment. This goal is dynamic and dependent of the threat.

The output is a list of combat power deployment options for each threat, with the associated degrees of freedom (e.g., time and range). This list of available options against each single threat is maintained with consideration of combined effects, synergy and usage constraints.
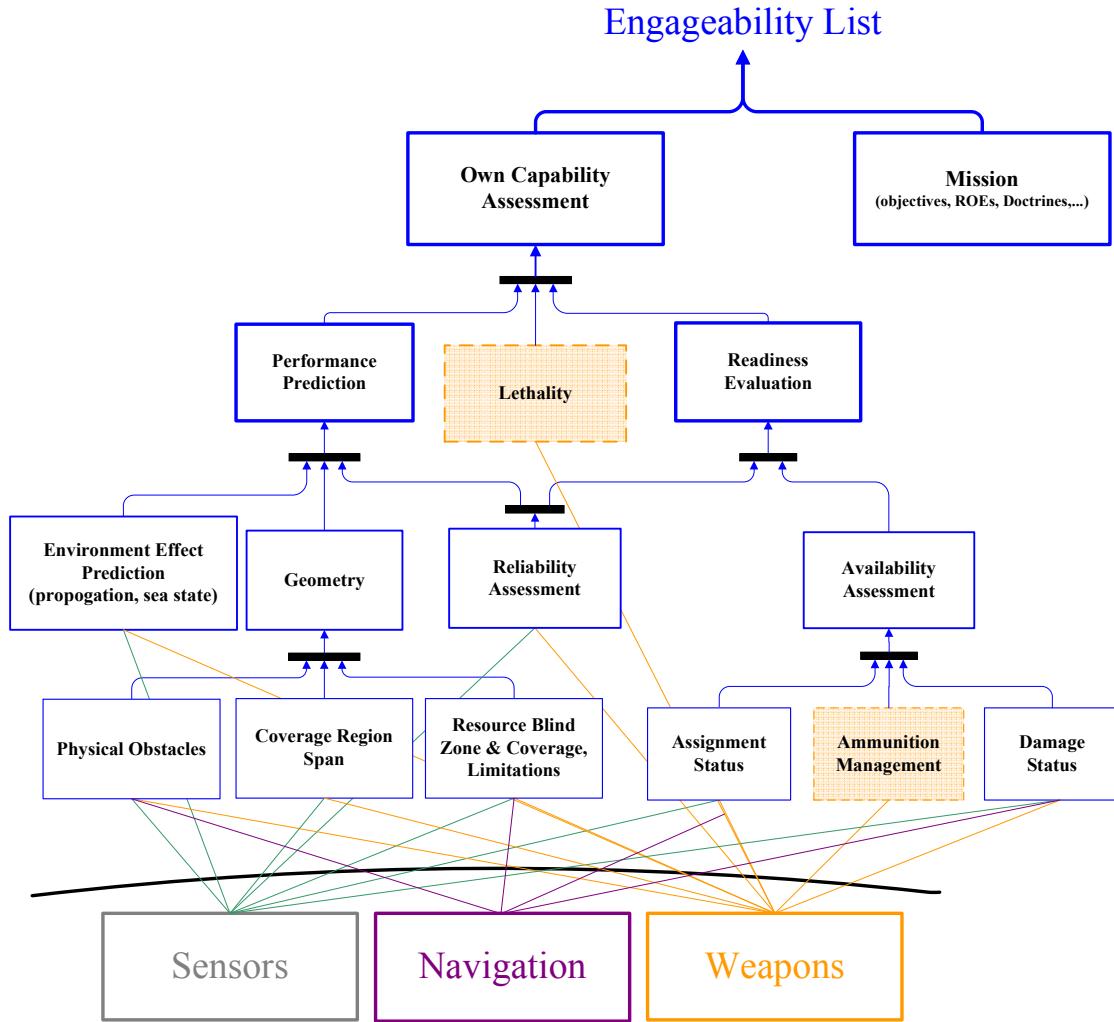
Figure 4: Engageability Assessment [10]

2.6   Combat Power Management

The combat power management can be decomposed into three phases (Figure 5) [10]:

1. **Response planning** ensures that one or more combat power resources are assigned to engage each target (i.e., atomic actions), including the assignment of supporting resources (e.g., sensors, communications). This involves assignment of both resources (i.e., pure allocation problem) and start and end times to activities (i.e., pure scheduling problem). In addition, response planning encompasses joint resource allocation and scheduling problems that generate a ranked engagement list of the targets for the response execution. A response (or engagement plan) is a coordinated (conflict-free) schedule (timeline) for the application of the selected CP components.

2. **Response Execution** involves executing in real-time the coordinated scheduled plan for the application of CP resources to counter targets within the current tactical situation.

3. **Response Monitoring** is required since the responses are executed in a dynamic environment, subject to uncertainty, changing goals, and changing conditions. As such, the actual execution contexts will be different from the projected ones, i.e., the ones that motivated the construction of the original response. Monitoring is essential to help detect, identify and handle contingencies caused by uncertainty and the changing nature of the environment. Also involved is the evaluation of the outcome of the executed actions. This boils down to performing damage assessment (e.g., capability) of engaged target(s) and assessing the damage inflicted to own-assets by opponent forces.
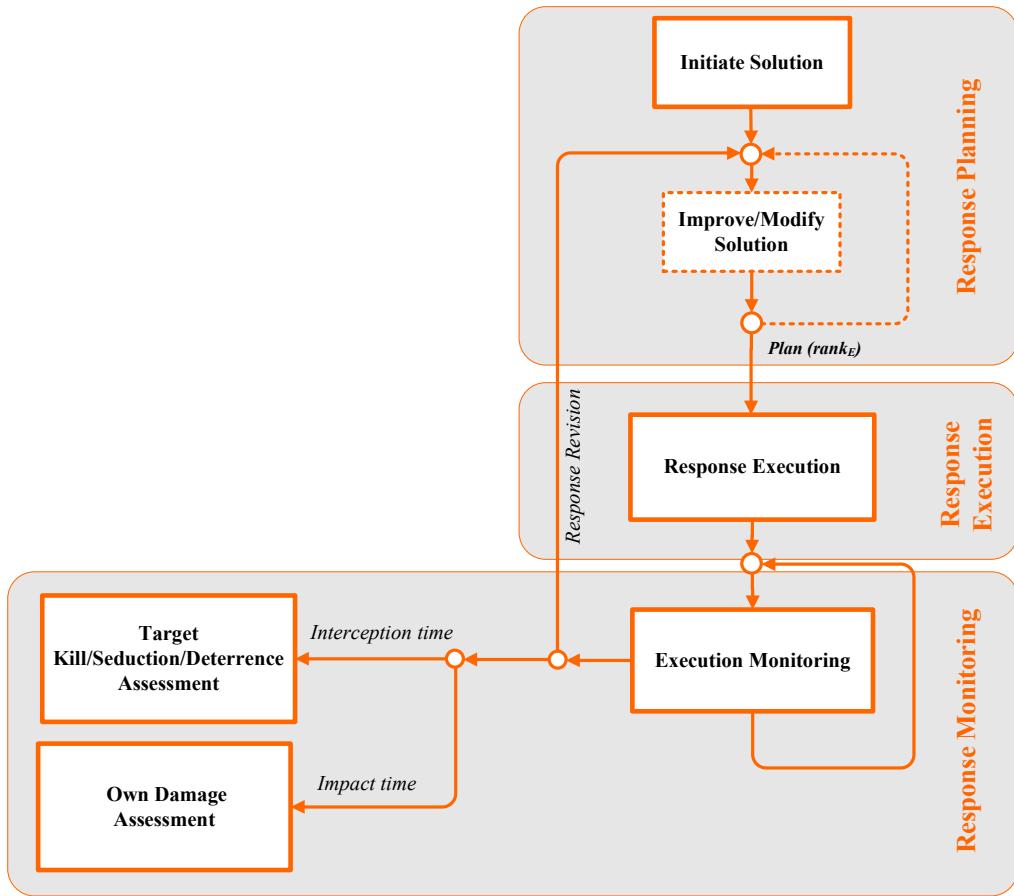
Figure 5: Application of Combat Power [10]

Combat power atomic actions can be grouped into three categories [12]:

1. **Deterrence** employs a series of measures such as manoeuvring platforms and radio warnings in order to convince a target that the consequences of coercion or armed conflict would outweigh the potential gains;

2. **Softkill measures** attempt to defeat a target through the use of deception, seduction, or confusion methods. Included is the use of chaff for seduction, distraction and re-acquisition as well as jamming; and

3. **Hardkill measures** include all weapons and armaments to achieve the physical destruction of a target. These include surface-to-surface missiles (SSM), surface-to-air missiles (SAM), guns, and torpedoes.

2.7   INCOMMANDS Command Decision Support Capability

The INCOMMANDS decision support system is a series of single-role displays that present information and support the necessary interactions required by each combat role in order to support decision-making from an individual perspective. An illustration of a conceptual INCOMMANDS prototype comprising multiple single-role displays is provided in Figure 6. The console is comprised of four interdependent types of displays: Threat Evaluation functional view, Combat Power Management functional view, physical view, and general purpose. The complementary advantages provided by each display are envisioned to augment the operator's decision-making capabilities. Currently only the TE, CPM, and physical displays have been implemented.
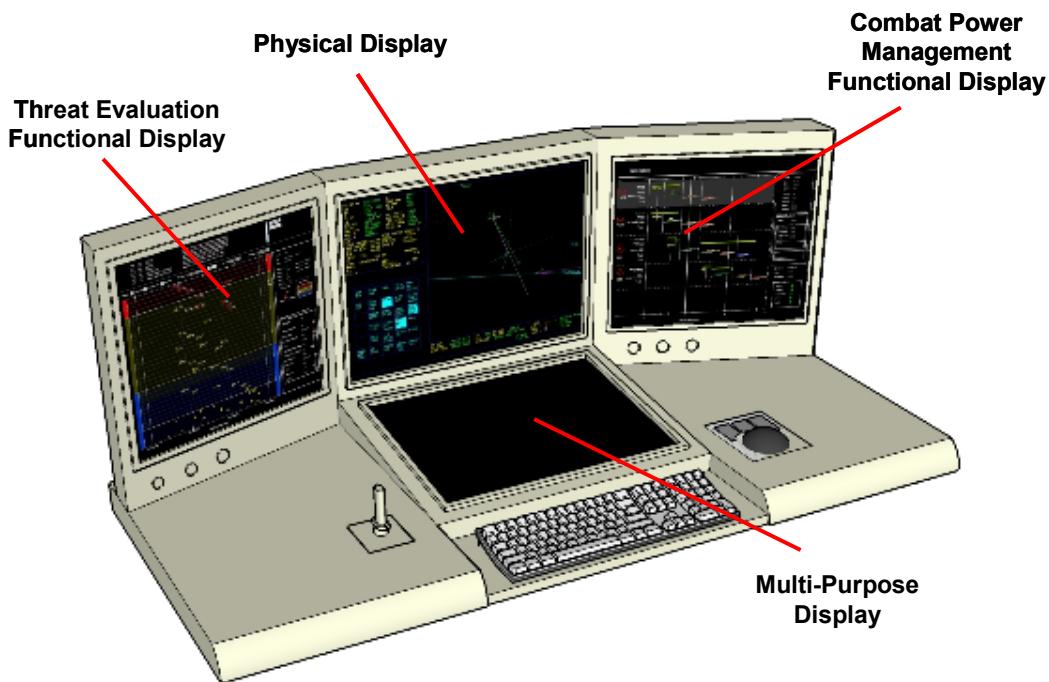
Figure 6:   Conceptual Console for Single-Role Displays

The TE functional display is comprised primarily of a 2-dimensional threat list. The list presents a relative ranking of threats based on their threat rating as calculated by the CDSC using the appropriate TE algorithm. To that end, the operator is able to monitor the complete threat picture as well as perform pre-emptive planning as required to avoid a potential engagement (Figure 7).
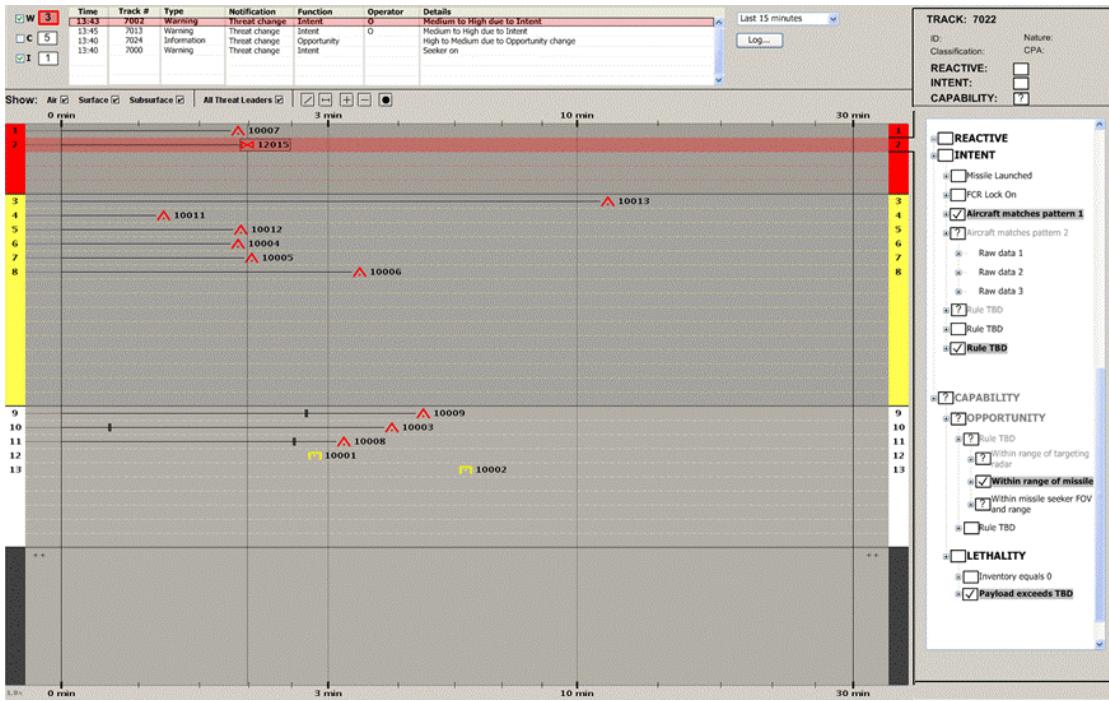
Figure 7:   Threat Evaluation Functional View

The CPM functional view is aimed at supporting the management and application of combat power through a series of decision aids. The CPM functional view consists of four predominant groupings: target-based view of engagement plans, resource-based view of engagement plans, engagement drill downs, and notifications. Figure 8 provides a depiction of the CPM functional view.
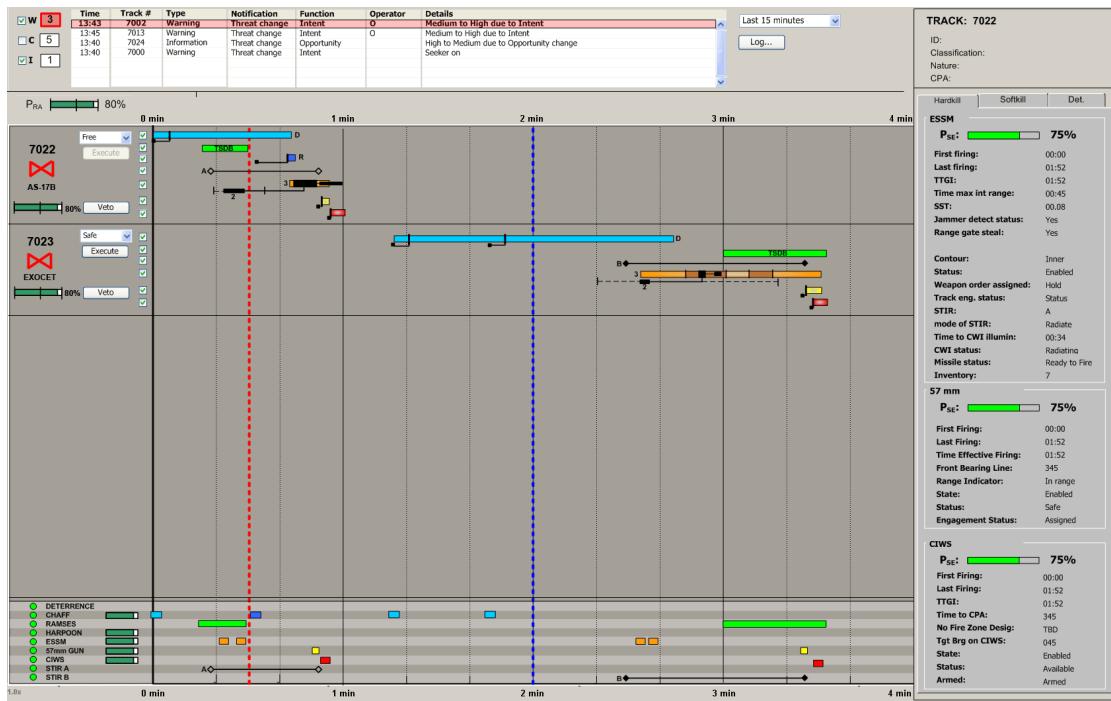
Figure 8:   Combat Power Management Functional View

3　　Evaluation Methodology

3.1　　General

Regardless of the level of analysis completed in support of designing an interface, experience has shown that particular problems only appear when the design is thoroughly evaluated. Consequently, evaluating the OMI design is key to a product's success. To that end, OMI evaluation has three main goals:

1.　　to assess the extent of the system's functionality

2.　　to assess the effect of the interface on the user

3.　　to identify problems (a.k.a. usability bugs)

Ideally, OMI evaluation should occur early and often during the design process. Early on, OMI assessments are employed by the HF analyst to gather and validate data on how operators conduct their work. As the OMI design progresses, assessments provide valuable input for analyzing initial design concepts and, in the later stages, to test specific tasks.

Research in Human Computer Interaction (HCI) has developed a multitude of evaluation techniques for analyzing and subsequently improving an OMI. Each methodology highlights different usability issues; therefore, HF analysts can choose and mix techniques to fit the needs and nuances of the design situation. In fact, testing with different techniques provides complementary results. A good evaluation process means major problems are caught early with minor problems ironed out as the OMI is being refined. It is easier and more cost effective to make product changes earlier rather than later in the design process.

Three categories of evaluation methods are:

1. **User Observations.** User observations are conducted in a lab using a representative sample of the eventual users performing tasks that depict how the system will be employed in the "real" world. Evaluators uncover problems by observing the participants completing the tasks. Two techniques are:

   a. **Controlled experiments.** Used to prove that varying an independent variable causes the effect observed in the dependent variable. Rigorous control ensures that uncontrolled variables do not affect the results and their interpretation. Statistical analysis allows inferences to be made concerning causal relationships between the manipulation of the independent variables and changes in the dependent variables.

   b. **Usability testing.** End users complete a set of real tasks with a prototype. HF analysts observe their performance and collect empirical data (e.g., errors made, difficulties experienced, and workload measures).

2. **Field Studies.** Field studies help to address a problem with evaluating a product in the lab: the failure to account for conditions, context, and tasks central to a product's real world use. Field studies involve the HF analyst studying systems in use on real tasks in real work settings. Two techniques are:

a. **Ethnography.** Based on the premise that human activities are socially organized; therefore, ethnography looks at patterns of collaboration and interaction. The ethnographer gathers data by passively observing and recording participants as they work in their natural environment using the available technology and tools. This includes focusing on social relationships and their effect on the nature of work. The goal is to identify routine practices, problems, and development possibilities within a given activity or setting.

b. **Contextual Inquiry.** Employs an interview methodology to gain knowledge of what users do in their real world context. HF analysts conduct interviews by observing and talking with target users as they work in order to record user tasks and dialogue, breakdowns and workarounds, and artefacts employed to help achieve work goals. The objective is to understand the users' motivations and strategies with the objective of creating representations of the work.

3. **Interface inspections.** Interface inspections involve HF analysts inspecting an OMI for usability problems according to a set of criteria, usually related to how individuals see and perform a task. These methods use judgment as a source of feedback when evaluating the system. Techniques include:

a. **Heuristic evaluation.** HF analyst(s) visually inspect the system and judge its compliance with recognized usability principles (heuristics). Non-compliant aspects are captured by describing the problem, its severity, and possible fixes.

b. **Cognitive walkthroughs.** HF analysts work through a task, step by step, and identify potential problems against psychological criteria. For each task, the analyst considers the interaction's impact on the user, the cognitive processes, and potential learning problems. For each action, data related to the users' goals, tasks, knowledge, the interface's visible state, and the relationships among these factors are recorded. The goal is to identify task sequences that may cause difficulties with learning the system.

c. **Task centered walkthroughs.** HF analyst(s) step through scenarios with tasks and user descriptions. At each step they question whether the user has the knowledge to do the step and whether it is believable that the user would actually do it. If the answer to either question is no, then a usability problem is reported.

d. **Pluralistic walkthroughs.** HF analyst(s) present participants with a hardcopy of the first screen encountered in a scenario. Participants independently write down the actions they would perform to complete the specified task. Next, the "right" answer is announced. The participants verbalize their responses and discuss potential usability problems due to "incorrect" answers. The process continues until the scenario is complete.

Evaluation early in the design stage (prior to any implementation) tends to be analytical involving design experts. As the design is slowly implemented, end users are brought into the evaluation as subjects. As vital as the analytical techniques are for filtering and refining the design, they are not a replacement for usability testing. Testing of this nature should be done at least once with end users performing representative tasks that the product has been designed to support.

3.2 INCOMMANDS TDP Evaluation Framework

The evaluation framework for the INCOMMANDS TDP involved a two step process to identify potential usability problems with the OMI design:

1. **Heuristic Evaluation:** Specific elements of the INCOMMANDS CDSC that are not compliant with the INCOMMANDS TDP: Human Factors Design and Evaluation Guide [2] were identified and recorded in a compliance matrix. Non compliant items were subsequently assigned a major or minor severity rating.

2. **Usability and Utility Testing:** The purpose of the trial was to provide user feedback for ease of use and utility to guide modifications for the future development cycles of the INCOMMANDS CDSC OMI. In preparation for these trials, an experimental protocol was generated and subsequently presented and accepted by the DRDC Human Research Ethics Committee (HREC).

These two evaluation techniques were proposed as part of the INCOMMANDS TDP since their findings are complementary. As previously mentioned, the Heuristic Evaluation ensures that the INCOMMANDS CDSC adheres to industry-accepted HCI principles and guidelines. The Usability and Utility Testing is not conducive to capturing these types of OMI issues. By including operational participation during the Usability and Utility Testing, the ability of the INCOMMANDS CDSC to satisfy the end user's goals and tasks can be assessed—which is not feasible via a Heuristic Evaluation.

These two evaluation techniques were chosen for the INCOMMANDS TDP in favour of the other available options for several reasons. For instance, field studies (i.e., ethonography, contextual inquiry) require observing the operators performing their tasks in their native environment. Access to the Naval operators conducting threat evaluation and combat power management activities on-board the HALIFAX Class frigate in a realistic environment is not easily achieved. With respect to the available interface inspection techniques, a Heuristic Evaluation was performed as opposed to a Cognitive Walkthrough since the INCOMMANDS CDSC is intended to be employed by trained operators; therefore, the learnability of the system was not an area of investigation. Furthermore, the GUI for the INCOMMANDS CDSC was developed based on goals and tasks identified through interactions with the Naval operators. Other walkthrough techniques (Task Based and Pluralistic) were not employed in favour of the Usability and Utility Testing involving the operational community. The functionality embedded in the current implementation of the INCOMMANDS CDSC was also not conducive to facilitating a walkthrough since the operators were limited to monitoring system-generated assessments with minimal available interactions.

The following sections provide an overview of the methodology utilized for Heuristic Evaluation and Usability and Utility Testing of the INCOMMANDS CDSC.

3.2.1 Heuristic Evaluation

3.2.1.1 General

There exist numerous principles fundamental to the design and implementation of effective interfaces for traditional OMI environments. These principles manifest in the form of guidelines and heuristics which can be differentiated as follows:

1. Heuristics are the motherhood rules and principles that describe common properties of usable interfaces. They are generally more abstract than traditional guidelines. Consequently, possessing UI design knowledge and experience helps to accurately understand and interpret them.

2. Guidelines can be construed as good practices within a general design domain (such as Windows in the case of the Microsoft Solutions product portfolio). Holistically, they are based broadly on the usability heuristics. Specifically, they provide useful low-level guidance on the design of usable interfaces in areas such as control design, branding elements, and window behaviour. Since they are generally more specific than heuristics, less design knowledge and experience is required to understand, interpret, and apply them.

3.2.1.2 Procedure

Numerous sources exist for describing heuristics and guidelines that could be used to inform the design of the INCOMMANDS CDSC OMI. The INCOMMANDS CDSC OMI design effort leveraged the guidance set forth by the INCOMMANDS TDP: Human Factors Design and Evaluation Guide [2]. This guide is an amalgamation of the following two reports:

1. **Command Decision Aid Technology (COMDAT) OMI Style Guide [9]**. The COMDAT OMI Style Guide was created to provide a common framework for new developments in Command Decision Aids. The style guide is designed to be used for all Maritime Command and Control systems and upgrades. The objective is to provide a common look and feel that is compatible with existing systems, yet accommodates new developments and knowledge.

2. **Development of Decision Aid Implementation Guidance for the INCOMMANDS Human Factors Design and Evaluation Guide [8].** This document is an extension to the aforementioned COMDAT OMI Style Guide and:

   a. incorporates recommended standards and guidelines that informs the OMI design and decision aiding concepts developed within the INCOMMANDS TDP to ensure consistency with Human Factors best-practice;

   b. provides a common OMI design guidance for existing decision aids, decision aids under development, and future decision aiding concepts, within the context of Maritime C2, including TE and CPM; and,

   c. provides general guidance, in terms of suggested metrics and tools, for the evaluation of a proposed OMI's compliance with the guidelines within the style guide.

The heuristic evaluation identified specific elements of the INCOMMANDS CDSC that are not compliant with the INCOMMANDS Human Factors Design and Evaluation Guide. It was performed by a HF analyst from CAE PS with results captured in a compliance matrix with the following columns:

1. **Compliance.** The Compliance column places each design feature in one of three categories as follows:

   a. **Not compliant.** The INCOMMANDS CDSC does not satisfy the objectives of the stated guideline;

b. **Out of Scope - Experimental**. Compliance to the guideline could not be evaluated via inspection. It was anticipated that the guideline could be verified through usability testing or experimentation; and

c. **Out of Scope.** Design features that are not implemented in the current INCOMMANDS CDSC build. Any instances in which the Scientific Authority and HF analyst agree that an element identified in the compliance matrix is out of the scope of the current INCOMMANDS CDSC, that design element should be identified and reserved for consideration in future development of the INCOMMANDS CDSC.

2. **Paragraph.** Column two identifies the paragraph number of the guideline INCOMMANDS Human Factors Design and Evaluation Guide (Version 1.0) that is relevant to the design feature.

3. **INCOMMANDS HF Design and Evaluation Guide.** Column 3 contains the text of the guideline that is relevant to the design feature.

4. **INCOMMANDS CDSC.** Column 4 describes each identified design feature of the INCOMMANDS CDSC OMI.

5. **Severity Rating.** Column 5 describes the severity of the non-compliance. A minor non-compliance is deemed to have minimal impact on the ability of the operator to complete the task at hand. A major non-compliance is considered to severely impact the ability of the operator to complete the task at hand.

3.2.2   Usability and Utility Testing

3.2.2.1 General

Although measures of system usability do not speak directly to the issue of decision making quality, they serve as a diagnostic tool for highlighting potential OMI problems that may have interfered with a participant's task relevant performance. In turn, OMI problems can result in poor decision making on the part of the operator. From the perspective of the participant, usability is important because it can make the difference between performing a task accurately and completely or not at all. From the perspective of the INCOMMAND TDP, usability is important because it can mean the difference between the success or failure of a system; poor usability can reduce the operational effectiveness and integrity of the human-machine system. In all cases, lack of usability can cost time and effort, and can greatly determine the success or failure of a system. Assessing the utility of the system is essential because it is important to know if the INCOMMANDS CDSC helps or hinders the operators' ability to do their job. A combination of questionnaires and interviews were used to collect usability and utility data from each participant.

The purpose of the Usability and the Utility Trial of the INCOMMANDS CDSC was to elicit feedback from Naval operators (ORO and SWC) in order to identify potential usability problems to be fixed with future builds as well as ascertain its ability to assist Naval operators with the conduct of TE and CPM functions on-board a Halifax Class Frigate. Furthermore, the testing investigated the impact that the new decision support system could have on operators' situation awareness and workload.

Through their involvement in the study, operators were able to contribute to the development, validation and implementation of decision support concepts to support the conduct of TE and CPM functions by CF personnel on-board a HALIFAX Class frigate.

The following sections outline the Usability and Utility Testing structured methodology that was used to assess development, validation and implementation of decision aid concepts designed as part of the INCOMMANDS CDSC.

3.2.2.2 Approach

The Technology Acceptance Model (TAM) was utilized as an approach for structuring the Usability and Utility Testing. The TAM is an information systems theory that models how users come to accept and use a technology. The model suggests that when users are presented with a system, a number of factors will influence their decision about how and when they will use it, notably:

1. **Perceived Utility (i.e. usefulness)** is defined as 'the degree to which a person believes that using a particular system would enhance his or her job performance' [6].

2. **Perceived Ease-of-Use** is defined as 'the degree to which a person believes that using a particular system would be free from effort' [6].

The TAM utilizes a questionnaire that has been assessed for robustness across populations and predictive validity. Studies have shown high reliability and good test-retest reliability and that the instrument had predictive validity for intent to use, self-reported usage and attitude toward use. The sum of this research has confirmed the validity of this instrument, and supports its use with different populations of users and different software choices.

3.2.2.3 Assessments of System Usability and Utility

To assess operator perceptions of the usability of the INCOMMANDS CDSC, questionnaires relating to the high-level usability aspects of both the CPM and the TE (e.g., suitability of screen design) were developed and administered. Ratings are based on a five-point Likert scale; ranging from 1: Strongly Disagree to 5: Strongly agree. A sample question is provided below. Complete usability questionnaires for TE and CPM functional views can be found in Annex C and Annex D respectively.

1. The size of the threat list is suitable.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

Similarly a questionnaire relating to the perceived utility of the workstation functions and capabilities was administered to assess operator perceptions of system utility. Ratings are based on a five-point Likert scale; ranging from 1: Strongly Disagree to 5: Strongly agree. A sample question is provided below. The complete utility questionnaire can be found in Annex E.

1. The Threat Evaluation View provides me with a more comprehensive assessment of all threats in the environment.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

In addition to measuring the utility of the INCOMMANDS CDSC, the complete utility questionnaires included a number of questions that queried the operators about their perceived situation awareness and workload. The Situation Awareness Rating Technique (SART) was also administered to assess operators' perceptions of their perceived situation awareness. Operators did not answer all the questions; therefore, scores for the SART were not calculated. Initially, the intent was to investigate and assess the operator's trust with the INCOMMANDS CDSC; however, this data was not collected in favour of focusing on the areas of utility, usability, situation awareness, and workload.

3.2.2.4 Equipment and Facilities

The Usability and Utility Testing was conducted at the Canadian Forces Maritime Warfare Centre in Halifax, Nova Scotia. The equipment employed was a portable version of the INCOMMANDS Command Decision Support (CDS) Laboratory. In addition, video and audio recordings were captured of both the participants and the presentation of information on the individual displays during each trial. As such, verbal dialogues and gestures could be correlated with the data being presented on the screen.

The INCOMMANDS CDS Lab used for the testing was not fully functional and therefore, did not allow the operator to interact fully with the information on either the TE or the CPM Displays. However, operators indicated that they were able to understand how the INCOMMANDS system could potentially augment their decision making capabilities.

3.2.2.5 Scenarios

Scenarios were developed for the practice and test sessions using STAGE Scenario. The practice scenario was a 15-minute low-complexity scenario with a small number of mid- and high-level threats and only two engagements. The trial scenario was a 20-minute high-complexity scenario that contained a number of medium- and high-level threats as well as five engagements.

3.2.2.6 Procedure

3.2.2.6.1 General

The complete Usability and Utility Testing transpired over three days; however, the total time commitment for each participant was approximately 2 hours. The following sections outline the procedure utilized as part of the Usability and Utility Testing.

3.2.2.6.2 Orientation Briefing

Following a brief introduction to each member of the experimental staff, the participants were given an overview of the general purpose of the trial, and were then given the opportunity to ask questions before signing the consent form (Annex B). After signing the consent form, participants were asked to provide some professional and personal background information (e.g., number of years of experience as an operator). Training of the participant and familiarization with the INCOMMANDS CDSC followed.

3.2.2.6.3 Training Session

In the training session, operators viewed the low complexity scenario and they were encouraged to interact with the system and to ask questions. At the end of the training session, operators were asked if they had any questions about the system. Once all questions were answered, the usability and utility trial scenario began.

3.2.2.6.4 Test Session

Operators were seated in the experimental testing room in front of the INCOMMANDS CDSC. Operators were given a detailed briefing by the SME, whose primary role was to act as the liaison between the experimental staff and the operators. The SME was an experienced Naval operator who is familiar with the decision support concepts and the functional displays of the INCOMMANDS CDSC prototype.

Following any questions the operator had regarding the information covered in the briefing, operators began the usability and utility trial. During the trial, participants were encouraged to provide subjective feedback about the quality of various aspects of the simulation environment and to comment on any ideas they might have about what would be a useful but currently not implemented in the physical and functional displays. The operator's responses were recorded (both audio and video). Immediately following the trial, each operator completed a threat evaluation and combat power usability and utility questionnaire. Following completion of the trial, the operators were debriefed by the experimental staff.

4   Heuristic Evaluation

4.1   General

The Heuristic Evaluation of the INCOMMANDS CDSC OMI was aimed at identifying non-compliances with the guidelines set forth by the INCOMMANDS TDP: Human Factors Design and Evaluation Guide [2]. The results are detailed in the compliance matrix located in Annex A. The matrix is only comprised of non-compliant guidelines for which the system does not satisfy their criteria; therefore, compliant guidelines are not present. This section provides an overview of these results and conclusions that can be drawn based on this evaluation.

4.2   Results

As captured in Annex A, the Heuristic Evaluation uncovered numerous design non-compliances with the OMI guidelines for the current build of the INCOMMANDS CDSC OMI. A significant portion of the non-compliant guidelines are classified as Major (i.e., significant obstacle for the operator to complete the task at hand or meet the objectives of the goal). The majority of items that were classified as Major non-compliancy issues are related to following categories of guidelines:

1. **Decision support (Sections 7 and 8).**   These guidelines are aimed at keeping the operators 'in the loop'. For example, the existing INCOMMANDS CDSC OMI does not provide operators with alternative action plans or allow operators to select their choice of action plans.

2. **Interactive control guidelines (Section 12.5)**. These guidelines provide the user the ability to remain 'in control' while providing appropriate feedback. The current implementation of the INCOMMANDS CDSC OMI performs the engagement assessments automatically without an explicit action required on the part of by the operator. As such, the system is "in control" as opposed to the operator.

3. **Data query (Section 12.3.3).**   Operators are not currently able to query the INCOMMANDS CDSC in order to retrieve and display data.

Many of the decision support guidelines will need to be evaluated further through other evaluation techniques. For example, experiments can be used to gather objective measures of the adequacy of OMI ease of use and useful as well as assess the adequacy of the operator's SA and workload.

The large number of non-compliances may be viewed as disconcerting. Development work completed to date on the INCOMMANDS CDSC has focused on establishing a functional version of the prototype in order to investigate technological and operational concepts. This prioritization of effort was in response to schedule and budget constraints. As such, many of the HCI specific concerns for ensuring a usable end version were not addressed during the development phase of the project. However, the requirements in the Human Factors Design and Evaluation Guide [2] are extremely important to ensure compliance with industry-accepted HCI best practices. As such, these non-compliances will need to be addressed if future versions of the INCOMMANDS CDSC are developed. Subsequent Heuristic Evaluations will also need to be

conducted to ensure these versions are compliant with the guidelines outlined in the Human Factors Design and Evaluation Guide [2].

Furthermore, a number of guidelines stated in the evaluation guide were not applicable to the current version of the INCOMMANDS CDSC OMI. Examples include the lack of particular controls (e.g., menu options) or other features such as maps and graphical displays. If in the future a more complete development of the INCOMMANDS CDSC is undertaken, it may be helpful for operators to have features, such as the ones previously highlighted, installed. Therefore, it is important that the Human Factors Design and Evaluation Guide [2] continue to guide any future versions of the INCOMMANDS CDSC.

Finally, compliance of the INCOMMANDS CDSC to numerous applicable guidelines stated in the Human Factors Design and Evaluation Guide [2] could not be confirmed via an inspection technique such as the Heuristic Evaluation methodology. These guidelines have been identified and should be verified through another complementary HCI evaluation technique such as a controlled experiment.

4.3   Conclusions

The results from the Heuristic Evaluation provide specific direction to support future development of the INCOMMANDS CDSC in order to improve the overall usability of the system. As such, any additional work to be completed on the system should attempt to improve the usability of the system by both fixing identified non-compliances as well as adding missing functionality.

Finally, there exist additional design aspects that are not covered by the current set of guidelines captured in the INCOMMANDS TDP: Human Factors Design and Evaluation Guide [2] (e.g., transparent overlays). Guidelines will need to be researched and included in the next version of the document for future implementations of this type of OMI element.

5 Usability and Utility Testing Results

5.1 General

Results stemming from the Usability and Utility Testing are presented in the following sections. These results have been broken down according to the following groupings for both the TE and CPM functional views:

1. Usability – Display of information; Usefulness of the information; Participants comments

2. Utility – Overall assessment of threats and engagement plans; Impact on workload, situation awareness and operations room communications

Furthermore, an overall assessment of impact of the TE and CPM functional views on perceived workload and situation awareness is presented.

5.2 Participants

Six active and qualified CF Naval operators between 37 and 50 years (M = 46 years) were recruited to participate in this trial. Operators were either qualified as ORO or SWC with five OROs and one SWC participating. The ORO and the SWC are the two primary ship combat operators (i.e., they are in charge of threat evaluation, engageability assessment, combat power management tasks) within the operations room of the HALIFAX Class frigate. The ORO is responsible for ensuring that the appropriate response is taken to counter any threat encountered by the ship. As such, the ORO evaluates the requirements for resources of each warfare area (air, surface, subsurface); resolving any conflicts that arise, to most effectively allocate those resources when conducting multi-warfare operations. The SWC manages two warfare areas (surface and air) including the assessment of threats, prioritization of targets, performance prediction of the above-water weapons and sensors as well as the planning and execution of response.

All operators had experience with the existing Command and Control System (CCS)-330. Participating operators were recruited from Halifax, N.S. and conducted the tasks while on duty; however, participation was voluntary.

5.3 Usability Questionnaire Results

5.3.1 TE Functional View

5.3.1.1 General

Questionnaire rating data was collated and summary statistics (mean and standard deviation) were calculated. Mean questionnaire results (N = 6) and standard deviations (eyelashes) for the Threat Evaluation functional display system are shown in Figure 9 and Figure 10. The following sections highlight the participants' feedback as gathered through the questionnaires.

5.3.1.2 Display of Information

Based on the questionnaire results, participants were in agreement that the size and number of swimlanes[1] were suitable and that the titles, labels and colours used were clear, easy to read and made sense with the exception of one participant who felt the lettering was too small. Participants were also in agreement that the cursor traveled at an appropriate speed and that they always knew where the cursor was. One participant reported that at times it was difficult to find the cursor. Participants agreed that it was easy to find important items quickly and that the information on the screen was clearly presented and was easy to understand.

The questionnaire results for the usability of the displayed information on the TE functional display are illustrated in Figure 9.
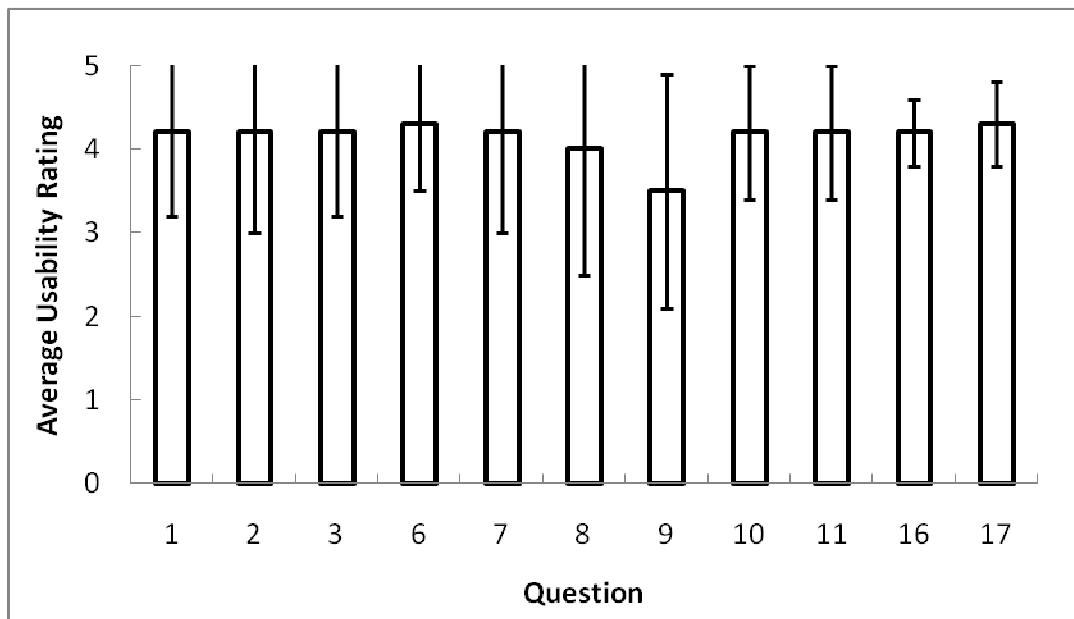
QUESTION LEGEND

1. Size of threat list is suitable.	9. I always know where the cursor is on the TE display.
2. Size of swimlanes is suitable.	10. The cursor always travels at an appropriate speed.
3. Number of swimlanes is suitable.	11. I can find important items quickly.
6. Titles and labels are clear.	16. Organization of information was clear.
7. Colours used on screen make sense to me.	17. Information was easy to understand.
8. Size of lettering on screen is easy to read.	

Figure 9: TE Questionnaire Results – Display of Information

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[1] Each threat that appears in the threat list on the TE functional display will be allocated to a "swimlane" that spans the length of time (or range) represented by the x-axis. Each threat (or swimlane) is assigned a relative threat ranking number with the highest threat ranked '1' at the top of the list.

5.3.1.3 Usefulness of the Information

The participants positively rated ease of use of the system, their comfort level when using the system, their understanding of what the system was doing at all times and an overall satisfaction with the system. Participants agreed that it was easy to toggle the x-axis scale between range and time and easy to expand/reduce the x-axis. Participants also agreed that they did not need to learn a lot about the display before they could use it.

The questionnaire results for usefulness of information on the TE functional display are illustrated in Figure 10.
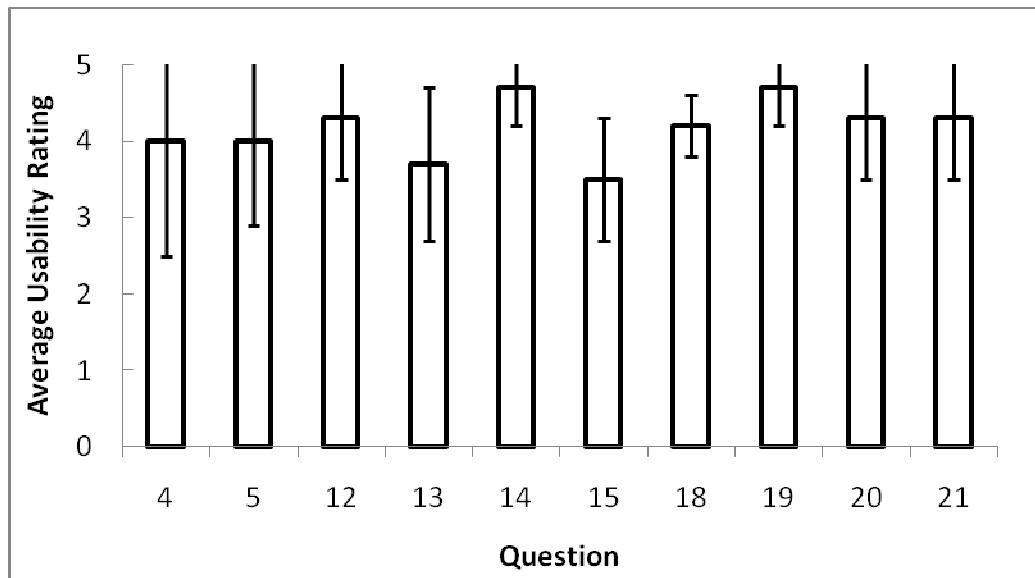
QUESTION LEGEND

4. I found it easy to toggle the x-axis scale between range and time.	15. The threat evaluation functional view has all the functions and capabilities I expect it to have.
5. I found it easy to expand/reduce the x-axis scale.	18. I knew what the threat evaluation functional view system was doing at all times.
12. I found the threat evaluation functional view easy to use.	19. In general, the system provides information users will use.
13. I needed to learn a lot about the threat evaluation functional view before I could use it.	20. It was simple to use this system.
14. I felt comfortable using the threat evaluation system.	21. Overall, I am satisfied with this system.

Figure 10: TE Questionnaire Results – Usefulness of Information

5.3.1.4 Participant Comments

Participant comments were recorded during the conduct of the trial. Of note, participants:

1. Stated that it was awkward to have to go to the bottom of the screen to expand/reduce the x-axis scale. It was suggested that the operator should have the option to expand/reduce the scale at either the top or the bottom of the screen.

2. Suggested that operators should have the ability to increase or decrease the number of swimlanes displayed.

3. Noted that different missile types should be represented with either different symbols or different colours.

4. Stated that the threat evaluation functional view interface was too cluttered. It was suggested that operators should have the option of selecting what information they would like to see displayed.

5. Suggested that there was no need for friendly or neutral entities to be displayed in the swimlanes.

6. Recommended that they would like some indication as to where a threat 'jumped' from when a category jump has occurred. It was suggested that the swimlane where the threat came from be highlighted.

7. Preferred the time-based x-axis compared to the range-based x-axis.

8. Suggested that information about the history of altitude of an aircraft would be useful.

9. Stated that they would prefer a 3-D threat evaluation functional display because this would allow the operators to see altitude aircraft are flying at.

10. Suggested that each operator should have the ability to tailor where information on the threat evaluation functional display is displayed.

11. Stated they would prefer mechanical functional changes (i.e., touch screen) to interact with the information on the display.

12. Indicated that the capability of a threat was more important than the hostile intent that a threat showed.

13. Suggested that they would prefer to use a joystick over a mouse to move the cursor.

14. Indicated that they would prefer to have the threat evaluation and the combat power management display combined into a single screen or presented side by side. Participants did not like having to continually look from side to side.

15. Stated that the information contained in the pop-up display was useful but it was difficult to read the information in the semi-transparent pop-up display when it was overlaying another target.

5.3.2   CPM Functional View

5.3.2.1 General

Questionnaire rating data was collated and summary statistics (mean and standard deviation) were calculated. Mean questionnaire results (N = 6) and standard deviations for the Combat Power Management functional display system are shown in Figure 11 and Figure 12. The following sections highlight the participants' feedback as gathered through the questionnaires.

5.3.2.2 Display of Information

Based on the questionnaire results, participants were in agreement that the size of the local engagement plan and the action was suitable and that the titles, labels and colours used were clear, easy to read and made sense. One participant felt the lettering, the local engagement plan and the actions were too small. Participants were also in agreement that the cursor travelled at an appropriate speed and that they always knew where the cursor was. One participant reported that at times it was difficult to find the cursor. Participants agreed that it was easy to find important items quickly and that the information on the screen was clearly presented and was easy to understand.

The questionnaire results for the usability of the displayed information on the CPM functional display are illustrated in Figure 11.
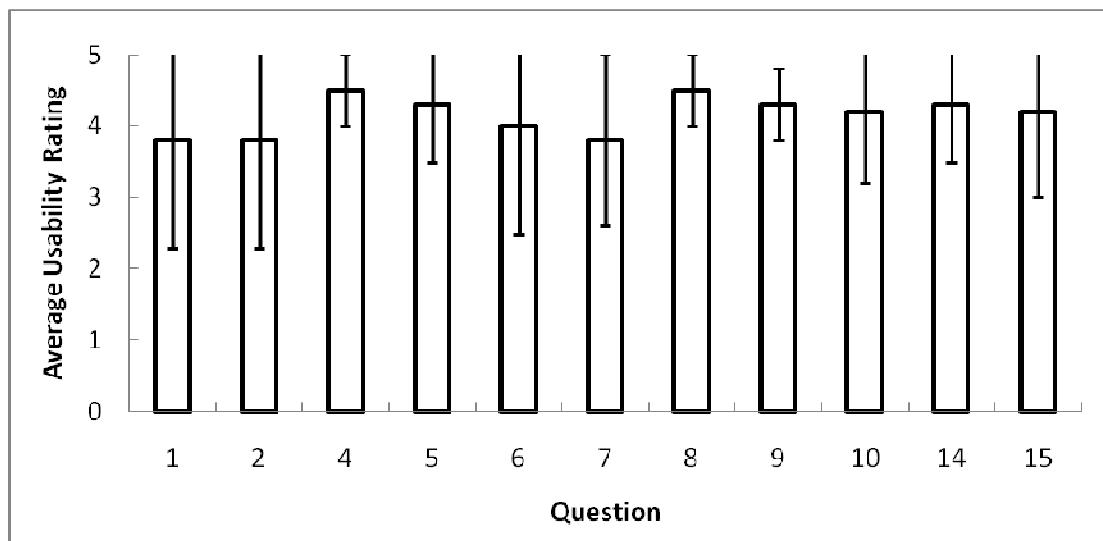
QUESTION LEGEND

1. Size of local engagement plan is suitable.	7. I always know where the cursor is on the CPM display.
2. Size of actions is suitable.	8. The cursor always travels at an appropriate speed.
4. Titles and labels are clear.	9. I can find important items quickly.
5. Colours used on screen make sense to me.	10. CPM display is easy to use.
6. Size of lettering on screen is easy to read.	14. Organization of information was clear.
	15. Information was easy to understand.

Figure 11: CPM Questionnaire Results – Display of Information

5.3.2.3 Usefulness of the Information

The participants positively rated ease of use of the system, their comfort level when using the system, their understanding of what the system was doing at all times and an overall satisfaction with the system. Participants agreed that it was easy to expand/reduce the x-axis. Participants also agreed that they did not need to learn a lot about the display before they could use it.

The questionnaire results for the usefulness of the information on the CPM functional display are illustrated in Figure 12.

QUESTION LEGEND

3. I found it easy to expand/reduce the x-axis scale.

11. I needed to learn a lot about the Combat Power Functional View before I could use it.

12. I felt comfortable using the Combat Power system.

13. The Combat Power Functional View has all the functions and capabilities I expect it to have.

16. I knew what the Combat Power Functional View system was doing at all times.17. In general, the system provides information users will use.

18. It was simple to use this system.

19. Overall, I am satisfied with this system.

Figure 12: CPM Questionnaire Results – Usefulness of Information

5.3.2.4 Participant Comments

Participant comments were recorded during the conduct of the trial. Of note, participants:

1. Liked the time-line presented on the combat power management engagement plan.

2. Liked the engagement plans comprising of actions that were provided.

3. Stated that they would like the ability to veto all actions and to control what actions will be executed.

4. Suggested that they would like to see the engagement plans for simultaneous missiles presented on the same lines (as opposed to having engagement plans stacked).

5. Stated that the combat power management display interface was too busy.

6. Expressed concerns that operators may not trust the engagement plans provided by the automation component of INCOMMANDS CDSC.

5.4   Utility Questionnaire Results

### 5.4.1   TE Functional View

5.4.1.1 General

Questionnaire rating data was collated and summary statistics (mean and standard deviation) were calculated. Mean questionnaire results (N = 6) and standard deviations (eyelashes) for the Threat Evaluation functional display system are in Figure 13 and Figure 14. The following sections highlight the participants' feedback as gathered through the questionnaires.

5.4.1.2 Overall Assessment of Threats

Overall, the participant ratings on the utility of the threat evaluation functional display were very favourable. All participants agreed that the threat evaluation functional display improved operators' ability to make decisions with respect to goals and processes pertaining to the assessment of threats in the environment. Additionally, all participants agreed that the threat evaluation view always made it clear where the threats were in relationship to the ownship and it was always evident when a threat made a category jump (e.g., from mid-level to a high-level). However, some participants felt that the threat evaluation view did not allow operators to form an accurate mental picture of their environment and did not allow operators to easily view all of the information required to evaluate all the threats. One participant reported that the TE functional view did not provide operators with a more comprehensive assessment of all threats, did not prevent operators from "tunnelling" on the highest priority threat, and did not allow operators to quickly and easily evaluate all the threats in the environment.

The questionnaire results for overall assessment of threats using the threat evaluation view are presented in Figure 13.
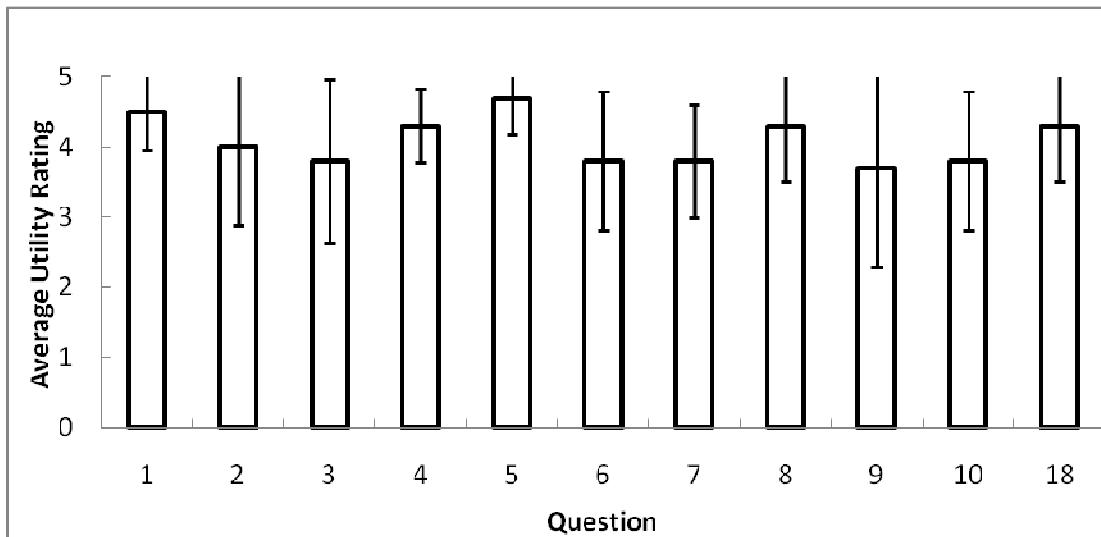
QUESTION LEGEND

1. Overall, the use of the Threat Evaluation View improved my ability to make decisions with respect to the goals and processes pertaining to the assessment of threat in the environment.

2. The Threat Evaluation View provided me with a more comprehensive assessment of all threats in the environment.

3. The Threat Evaluation View allowed me to form an accurate mental picture of my environment.

4. The Threat Evaluation View always made it clear where the targets were in relationship to the ownship.

5. It was always clear when a threat made a category jump (e.g., from mid-level threat to high-level threat).

6. The Threat Evaluation View helped me to avoid "tunnelling" on the highest priority threat.

7. It was useful having the ability to switch between a time and a range scale (nautical miles) on the Threat Evaluation View.

8. The information in the roll-over menu helped me to quickly gather information about the threats in the environment.

9. The interface on the Threat Evaluation View allowed me to easily view all of the information required to evaluate all the threats in my environment.

10. I found that the location of all the information on the Threat Evaluation View interface allowed me to quickly and easily evaluate all the threats in my environment.

18. Overall, the Threat Evaluation View is a valuable tool for evaluating threats in the environment.

Figure 13: TE Questionnaire Results – Overall Assessment of Threats

Participant comments were recorded during the conduct of the trial as it pertained to the utility of the TE functional view for assessing threats in the environment. Of note, participants:

1. Stated that the threat evaluation view would be most important in a littoral setting.

2. Noted that the threat evaluation view was extremely useful for assessing threats in the environment. Participants raised concern over the potential negative impact of providing the operator with too much information.

3. Expressed concern about how they would develop a proper level of trust in the system and avoid either mistrust or distrust.

4. Stated that the threat evaluation view prevented operators from "tunnelling in" on the threat closest in proximity to the ship. In many instances, the highest threat is assumed to be the contact closest to the ship which may not necessarily be true.

5. Suggested that having the threat explicitly identified on the threat evaluation view (e.g., Mig 20) would be useful.

6. Noted that the arrow that appears when a threat makes a category jump is too small.

7. Stated that because capability is more important than intent, they suggested that the order in the drill-down pane be flipped to reflect this.

8. Suggested that having course "be true" (e.g., course heading of 45° instead of -15°) would be more useful.

5.4.1.3 Impact on Workload, Situation Awareness and Operations Room Communications

Participants reported that their overall workload decreased when they were using the threat evaluation view compared to using only the physical display. They also reported that overall workload would decrease in a high workload situation relative to a low workload situation. Participants also indicated that their overall situation awareness was better when using the threat evaluation view compared to using only the physical display. Participants also suggested that their overall situation awareness would increase in a high workload situation compared to a low workload situation. Participants also stated that they would feel comfortable using the threat evaluation view under time pressure. Finally, participants reported that the presence of the threat evaluation view would not interfere with the flow of communications in the operations room and that the threat evaluation view would make the operator's job easier.

The questionnaire results for workload, situation awareness and operations room communications when using the threat evaluation functional display can be found in Figure 14.
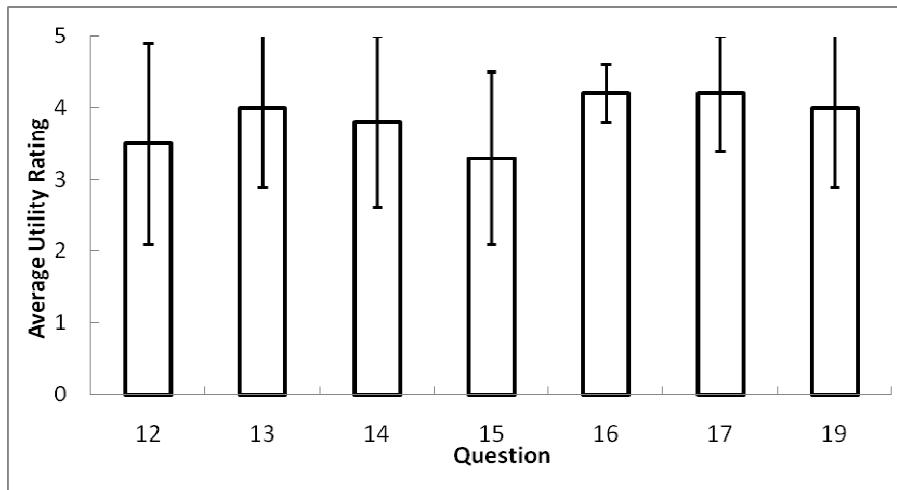
QUESTION LEGEND

12. The threat evaluation view decreased my overall workload.	16. The presence of the threat evaluation view will not interfere with the flow of communication in the operations room.
13. The threat evaluation view would decrease my overall workload more in a high workload situation relative to a low workload situation.	17. I would feel comfortable using the threat evaluation view under time pressure.
14. The threat evaluation view increased my overall situation awareness.	19. Overall, the threat evaluation view will make the operator's job easier.
15. The threat evaluation view would increase my overall situation awareness more in a high workload situation relative to a low workload situation.	

Figure 14: TE Questionnaire Results – Impact on Workload, SA, & Ops Room Communications

Participant comments were recorded during the conduct of the trial as it pertained to the impact of the TE functional display on workload, situation awareness, and operations room communications. Of note, participants:

1. Reported that the physical display is needed in conjunction with the threat evaluation view in order to provide the operator with good situation awareness. They suggested that the physical display helps provide an "overall picture" of the environment and that the threat evaluation view provides more information about specific threats. The physical display provides information about friendly units, consorts, etc. whereas; the threat evaluation view does not provide this information.

2. Stated that the threat evaluation view would actually decrease the need for communication in the operations room.

3. Suggested that having more than one pop-up display would allow the operator to compare information across tracks and this would likely lead to better situation awareness.

4. Noted seeing the threats ranked on the threat evaluation view lowered their workload.

5. Suggested that having the threat evaluation view would not necessarily reduce attentional demands but it may free up attentional demands that can be allocated to other tasks.

5.4.2   CPM Functional View

5.4.2.1 General

Questionnaire rating data was collated and summary statistics (mean and standard deviation) were calculated. Mean questionnaire results (N = 6) and standard deviations (eyelashes) for the CPM functional display system are in Figure 15 and Figure 16. The following sections highlight the participants' feedback as gathered through the questionnaires.

5.4.2.2 Overall Assessment of Engagement Plans

Participants' ratings for the engagement plans presented on the combat power management display were very favourable. Participants reported that the combat power management view improved their ability to make decisions with respect to management and application of combat power and improved their ability to generate an 'optimal' global engagement plan. Participants said that the interface would allow them to easily view all of the information required to evaluate the presented engagement plan and to determine if the plan would be successful. Further, participants stated that the location of the information on the combat power management display allowed them to quickly and easily evaluate the engagement plan. Finally, two participants reported that the combat power management display would not be helpful for assessing the outcome of an engagement.

The questionnaire results of engagement plans presented on the combat power management view can be seen in Figure 15.
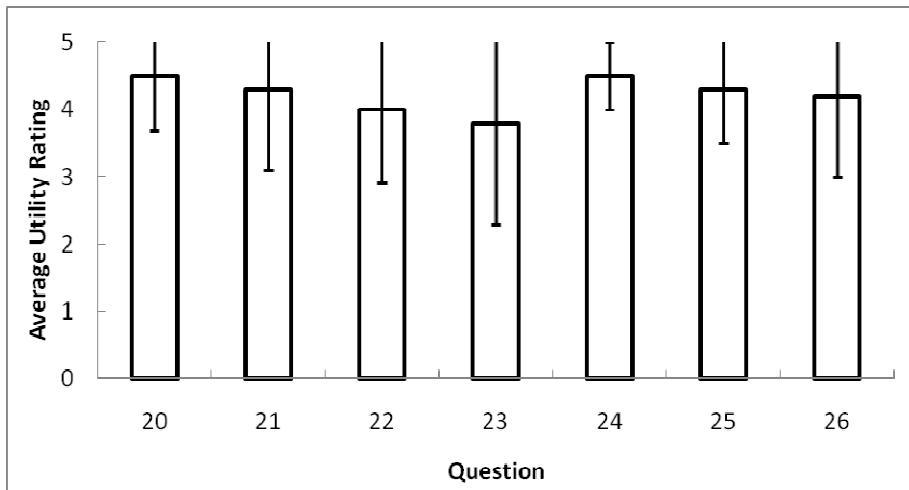
20. Overall, the Combat Power Functional View would improve my ability to make decisions with respect to the management of combat power.

21. Overall, the use of the Combat Power Functional View would improve my ability to make decisions with respect to the application of combat power.

22. The Combat Power Functional View would improve my ability to generate an 'optimum' global engagement plan.

23. During the execution of a combat power plan, the Combat Power Functional View would help me to assess the outcome of an engagement.

24. The interface on the Combat Power Functional View allowed me to easily view all of the information required to evaluate the engagement plan presented on the display.

25. The interface on the Combat Power Functional View allowed me to easily view all of the information required to evaluate whether the presented engagement plan would be a successful plan.

26. I found the location of all the information on the Combat Power Functional View interface allowed me to quickly and easily evaluate the engagement plan presented on the display.

Figure 15: CPM Questionnaire Results – Overall Assessment of Engagement Plans

Participant comments were recorded during the conduct of the trial as it pertained to an overall assessment of the engagement plan. Of note:

1. A single participant suggested incorporating the combat power management and the threat evaluation displays into one display or have the two monitors adjacent to one another.

2. A single participant stated that the font used on the drill-down menu on the right-hand side of the monitor was too small and this made it very difficult to read.

3. Participants suggested that a visual prompt warning the operators when an engagement will occur would be useful (e.g., launch chaff in ten seconds).

4. Participants said they would like to have evasive manoeuvres (e.g., moving the ship to another location) as one of the options on the combat power management view.

5. A single participant felt the default time line on the combat power management view was too small and that the plans were only visible for a short period of time.

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5.4.2.3 Impact on Workload, Situation Awareness and Operations Room Communications.

Participants agreed that their overall workload decreased when they were using the combat management view compared to using only the physical display. They also reported that overall workload would decrease in a high workload situation relative to a low workload situation. Participants also indicated that their overall situation awareness was better when using the combat power management view compared to using only the physical display. However, one participant reported that the combat power functional view would not increase his situation awareness because he would use the physical display for his situation awareness. Participants also suggested that their overall situation awareness would increase in a high workload situation compared to a low workload situation. Participants also stated that they would feel comfortable using the combat power management view under time pressure. Finally, participants reported that the presence of the combat power management view would not interfere with the flow of communications in the operations room and that the combat power management view would make the operator's job easier.

The questionnaire results for workload, situation awareness and operations room communications when using the combat power management functional display can be found in Figure 16.
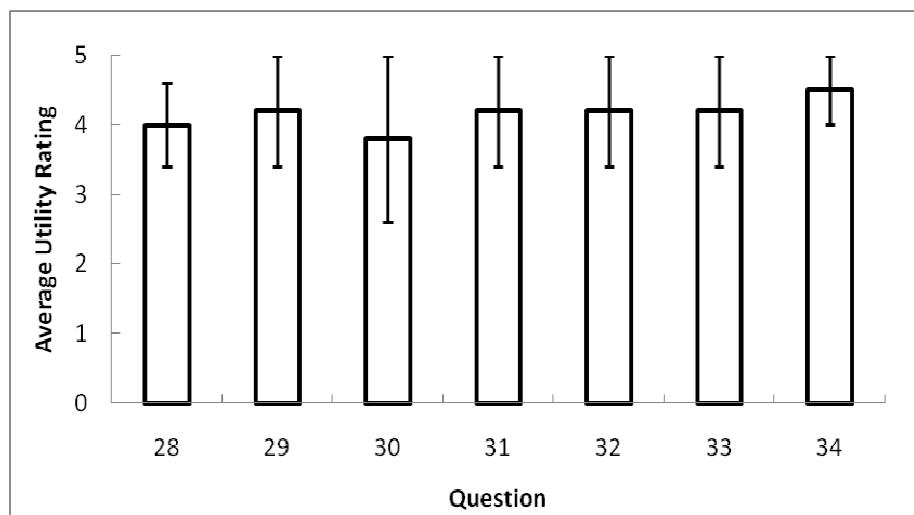
QUESTION LEGEND

28. The Combat Power Functional View would decrease my overall workload.

29. The Combat Power Functional View would decrease my overall workload more in a high workload situation relative to a low workload situation.

30. The Combat Power Functional View would increase my overall situation awareness.

31. The Combat Power Functional View would increase my overall situation awareness more in the high workload situation relative to the low workload situation.

32. The presence of the Combat Power Functional View would not interfere with the flow of communication in the operations room.

33. I would feel comfortable using the Combat Power Functional View under time pressure.

34. Overall, the Combat Power Functional View is a valuable tool for managing and applying combat power.

Figure 16: CPM Questionnaire Results – Impact on Workload, SA & Ops Room Communications

Participant comments were recorded during the conduct of the trial as it pertained to the impact of the CPM functional display on workload, situation awareness, and operations room communications. Of note, participants:

1. Stated that the combat power management view in conjunction with both the physical and threat evaluation display would improve overall situation awareness.

2. Reported that the combat power management view would actually decrease the need for communications in the operations room.

3. Reported that having the combat power management view would reduce the amount of attentional resources required for combat power management and in turn, this would allow operators to direct their attention to other operational tasks.

4. Indicated that the combat power management view would be most useful for multiple engagements.

5.4.3 Overall TE and CPM View

5.4.3.1 Impact on Workload and Situation Awareness

Participants reported that together, the threat evaluation and combat power management views would decrease overall workload and increase overall situation awareness. The questionnaire results for overall workload and situation awareness for the threat evaluation and combat power management view can be found in Figure 17.
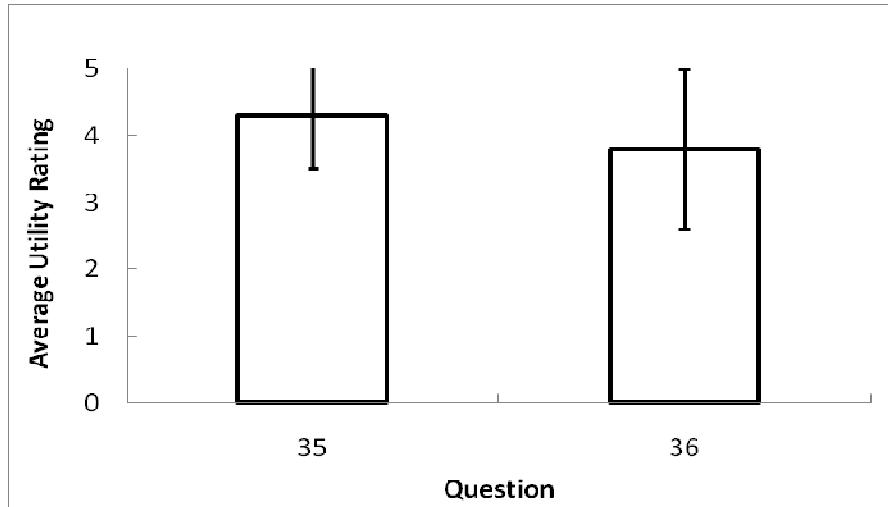
QUESTION LEGEND

35. Overall, both the Threat Evaluation View and the Combat Power Functional View would decrease my workload.	36. Overall, both the Threat Evaluation View and the Combat Power Functional View would increase my situation awareness.

Figure 17: TE & CPM Questionnaire Results – Impact on Workload and SA

Participant comments were recorded during the conduct of the trial as it pertained to the impact of both the TE and CPM functional displays on workload and situation awareness. Of note, participants:

1. Agreed that the INCOMMANDS CDSC is a much better system than the one currently being used.

2. Stated that the INCOMMANDS CDSC would greatly reduce workload and increase overall situation awareness.

5.4.4   Summary

Overall, the feedback gathered was very positive and further supports that the proposed INCOMMANDS OMI concepts are in line with the current operational requirements of the ORO and SWC Naval operators. To that end, the observations can be summarized as follows:

1. The participants positively rated ease of use of the system, their comfort level when using the system, their understanding of what the system was doing at all times and an overall satisfaction with the system.

2. Utility ratings of both the TE and CPM functional views were favourable.

3. Participants reported that their overall workload decreased when they were using the INCOMMANDS CDSC compared to using only the physical display. They also reported that overall workload would decrease in a high workload situation relative to a low workload situation.

4. Participants indicated that their overall situation awareness was better when using the INCOMMANDS CDSC compared to using only the physical display. Participants also suggested that their overall situation awareness would increase in a high workload situation compared to a low workload situation.

5. Participants stated that they would feel comfortable using the INCOMMANDS CDSC under time pressure.

6. Participants reported that the presence of the INCOMMANDS CDSC would not interfere with the flow of communications in the operations room and that the threat evaluation view would make the operator's job easier.

Most participants felt that they would prefer to have spent more time with the INCOMMANDS CDSC in order to get a better appreciation of how they would use the system in a littoral setting. Participants said they liked how the threat evaluation and combat power management applications were presented separately because this allowed them to have a better overall mental picture of events occurring in the environment and how they might respond to a target. Even though responses were positive, participants did have recommendations for how the system could be improved. For example, participants wanted to know explicitly what the threat was (e.g., Mig 20) and they wanted to have more freedom to tailor the displays to suit individual operator's needs.

6   Conclusion Material

6.1   General

The primary objective of this evaluation effort was to both identify usability problems with and determine the utility of the INCOMMANDS CDSC. The methodology employed two complementary techniques: Heuristic Evaluation and Usability and Utility Testing. To that end, the evaluations collectively:

1. Identified several usability problems related to the set of established OMI guidelines which in turn provide distinct focal points for the development of future versions of the INCOMMANDS CDSC; and

2. Collected operator feedback regarding the usability and utility of the INCOMMANDS System as it pertains to the performance of TE and CPM in the 'real world';

Furthermore, the Usability and Utility Testing provided a significant series of lessons learned that would provide useful direction for future experiments.

6.2   Conclusions

Based on the evaluation of the INCOMMANDS CDSC, it is concluded that:

1. Both evaluation techniques provide complementary insight into improving the INCOMMANDS CDSC. The Heuristic Evaluation helps to ensure that the design of system is compliant with HCI best practices. Whereas the Usability and Utility Testing with Naval operators ensures that contextual feedback is obtained which is lacking from the former evaluation technique.

2. The results from the Heuristic Evaluation provide specific direction to support future development of the INCOMMANDS CDSC in order to improve the overall usability of the system. As such, any additional work to be completed on the system should attempt to improve the usability of the system by both fixing the identified non-compliances as well as adding the missing functionality.

3. Based on the participant feedback received during the Usability and Utility Testing, the following preliminary conclusions can be postulated (additional studies are recommended to further validate these claims):

   a. The proposed INCOMMANDS CDSC OMI concepts are in line with the current operational requirements of the ORO and SWC Naval operators and would make their job easier.

   b. The participants positively rated ease of use of the system, their comfort level when using the system, their understanding of what the system was doing at all times and an overall satisfaction with the system.

   c. Overall workload would decrease when using the INCOMMANDS CDSC compared to using only the physical display for TE and CPM activities. Furthermore, overall

workload would decrease in a high workload situation relative to a low workload situation.

d. Overall situation awareness would improve when using the INCOMMANDS CDSC compared to using only the physical display. Overall situation awareness would increase in a high workload situation compared to a low workload situation.

e. The INCOMMANDS CDSC can be employed in situations subject to time pressure.

f. The INCOMMANDS CDSC would not interfere with the flow of communications in the operations room.

6.3   Recommendations

Stemming from the HF evaluation of the INCOMMANDS CDSC, the following recommendations are put forth:

1. Improve the INCOMMANDS CDSC based on the direction summarized in this report; and

2. Conduct additional evaluations with other techniques to both verify incremental improvements to the OMI design as well as substantiate initial conclusions regarding the potential benefits afforded by the INCOMMANDS CDSC as stated herein. The proposed experimental plan in Annex F is a good starting point for further evaluations.

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Annex A   Heuristic Evaluation Compliance Matrix

A.1   General

The results from the Heuristic Evaluation of the INCOMMANDS CDSC are summarized in the compliance matrix in this Annex. The column headings for the compliance matrix are the following:

1. **Compliance.** The Compliance column places each design feature in one of three categories as follows:

    a. **Not compliant.** The INCOMMANDS CDSC does not satisfy the objectives of the stated guideline;

    b. **Out of Scope - Experimental.** Compliance to the guideline could not be evaluated via inspection. It was anticipated that the guideline could be verified through usability testing or experimentation; and

    c. **Out of Scope.** Design features that are out of the current INCOMMANDS CDSC build. Any instances in which the Scientific Authority and HF analyst agree that an element identified in the compliance matrix is out of the scope of the current INCOMMANDS CDSC, that design element should be identified and reserved for consideration in future development of the INCOMMANDS CDSC

2. **Paragraph.** Column two identifies the paragraph number of the guideline INCOMMANDS Human Factors Design and Evaluation Guide (Version 1.0) that is relevant to the design feature.

3. **INCOMMANDS HF Design and Evaluation Guide.** Column 3 contains the text of the guideline that is relevant to the design feature.

4. **INCOMMANDS CDSC.** Column 4 describes each identified design feature of the INCOMMANDS CDSC OMI.

5. **Severity Rating.** Column 5 describes whether the severity of the non-compliance. A minor non-compliance is deemed to have minimal impact on the ability of the operator to complete the task at hand. A major non-compliance is considered to severely impact the ability of the operator to complete the task at hand.

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Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
7 Electronic Support System (ESS) OMI DESIGN GUIDELINES				
7.1 GENERAL DESIGN GOALS				
7.1.1 EMPLOY OPERATOR CENTERED PRINCIPLES				
Experimental - Out of Scope	7.1.1.3	The ESS shall help or enable the operators to carry out their responsibilities and tasks safely, efficiently, and effectively. [Carrying out a task effectively means producing the desired result. Carrying out a task efficiently means that the desired result is produced with a minimum of waste (usually in relation to time)].	These measures would have to be collected and analyzed during the experimental phase.	TBD
Experimental – Out of scope	7.1.1.4	The operator shall always have final authority over the allocation of ESS functions (i.e., task allocated to human and/or system).	The current INCOMMANDS CDSC does not support final authority over functions to the operator. A future version is intended to allow operators to have final authority over all INCOMMANDS CDSC functions.	Minor
Experimental - Out of Scope	7.1.1.5	Functions shall be automated only to attain greater overall effectiveness, efficiency, reliability, simplicity, economy, and system safety without reducing human involvement, situation awareness, or human performance in carrying out the intended task.	Performance measures and situation awareness measures would have to be collected and analyzed during the experimental phase.	TBD
7.1.2 OPTIMIZE HUMAN-SYSTEM INTERACTION				
Not Compliant	7.1.2.1	Inform the operator of system failure or degradation; inform the operator if potentially unsafe modes are manually selected; do not interfere with manual task performance; and allow for manual override.	The current INCOMMANDS CDSC does not inform the operator of system failure, or degradation or if any unsafe modes are manually selected. The system does not allow for manual override.	Major

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Experimental - Out of Scope	7.1.2.5	ESS functioning shall not increase the demands for cognitive resources (thinking or conscious mental processes).	The NASA- TLX, and usability and utility questionnaires would need to be used to assess operator workload.	TBD
Experimental - Out of Scope	7.1.2.6	Extreme levels of workload (low or high) due to ESS functioning shall be avoided (to maximize operator-in-the-loop and reduce automation bias).	The NASA-TLX and performance measures would need to be used to assess workload and to ensure maximum operator-in-the-loop.	TBD
Experimental - Out of Scope	7.1.2.7	Operator interaction with the ESS shall not require the operator to take significant amounts of attention away from the primary task.	The performance measures would need to be used to assess if the ESS requires operators to take significant amounts of attention away from the primary task.	TBD
Experimental - Out of Scope	7.1.2.8	ESS shall not interrupt at inappropriate times such as during periods of high workload or during critical moments in a process.	The performance measures would need to be used to assess if the ESS interrupts operators during periods of high workload or critical moments.	TBD
Experimental - Out of Scope	7.1.2.9	An ESS task shall be less difficult to carry out than the manual task it replaces.	The performance measures would need to be used and the usability and utility questionnaires were used to assess task difficulty when using the ESS.	TBD
Experimental - Out of Scope	7.1.2.10	Data that are needed by the operator shall be easily accessible.	The performance measures would need to be used and the usability and utility questionnaires were used to assess if data are easily accessible.	TBD
Experimental - Out of Scope	7.1.2.11	The ESS shall allow the operator to interact directly with objects which are important to the operator's tasks	The performance measures would need to be used and the usability and utility questionnaires were used to assess if operators are able to interact directly with objects important to operator's task.	TBD
7.1.3 PROMOTE ESS ROBUSTNESS AND RESILIENCE TO OPERATOR ERROR				

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Experimental - Out of Scope	7.1.3.1 – 7.1.3.14	These items focus on ESS robustness and resilience to operator error.	Performance measures, trust, workload, and situation awareness questionnaires would need to be used and usability and utility questionnaires were used to assess these items.	TBD
7.1.3 SUPPORT OPERATOR MONITORING OF ESS FUNCTIONING				
Not Compliant	7.1.4.1	Informative feedback shall be given in case of an ESS failure; such as the likely cause and/or location of the failure	The current INCOMMANDS CDSC does not provide feedback in case of an ESS failure.	Major
Not Compliant	7.1.4.2	The ESS shall be designed so that operators are able to monitor the ESS and the functionality of its hardware and software, including the display of status and trend information, as needed	The current INCOMMANDS CDSC does not allow operators to monitor the ESS and the functionality of its hardware and software.	Major
Experimental - Out of Scope	7.1.4.4	This item deals with operator cognitive load issues when monitoring the ESS.	Workload measures would need to be used to assess this item.	TBD
Not Compliant	7.1.4.7	The ESS shall provide some type of indication the system is still being monitored by some automatic system.	The current INCOMMANDS CDSC does not provide indication that the system is being monitored by some automatic system.	Minor
Not Compliant	7.1.4.8	Critical ESS functions shall be independently monitored by the operator. A critical function is a function that can cause system failure when a malfunction is not attended to immediately.	The current INCOMMANDS CDSC does not provide system failure notices.	Major
Not Compliant	7.1.4.13	The ESS shall provide means to indicate to the operator that data are missing, incomplete, unreliable, or invalid or that the system is relying on backup data.	The current INCOMMANDS CDSC does not show data that are missing, incomplete, unreliable or invalid or if the system is relying on backup data.	Major
7.2 EMPLOY OPERATOR-CENTERED OMI DESIGN				
Experimental - Out of	7.2.1 – 7.2.2	These two items assess if the information displays	Questionnaires and usability and utility	TBD

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Scope		are intuitive, easy to understand and easy to use and if the ESS is simple for operators to learn.	questionnaires were used to assess these two items.	
7.3 SUPPORT DIFFERENT MODES OF OPERATION				
Out of Scope	7.3.3	Seldom-used ESS modes and functions shall be clearly identified. As ESSs become more complex with many modes and functions, the cognitive burden caused by the need for mode awareness increases. Seldom-used ESS modes and functions will pose the largest burden on the operator because of a lack of familiarity. Enabling the operator to immediately recognize the purpose of ESS modes and functions can lessen this burden.	The current INCOMMANDS CDSC does not have seldom-used modes. However, as the system evolves seldom-used modes and function will need to be clearly identified.	Minor
Out of Scope	7.3.7	The ESS shall alert the operator to the implications of interactions between modes, especially when they are potentially hazardous.	The current INCOMMANDS CDSC does not alert the operator to the implications of interactions between modes.	Major
Out of Scope	7.3.8	The ESS shall either prevent the use of potentially unsafe modes or alert the operator that a particular mode may be hazardous.	The current INCOMMANDS CDSC does not prevent the use of potentially unsafe modes or alert the operator that a particular mode may be hazardous.	Major
7.4 PROVIDE SYSTEM RESPONSE AND FEEDBACK				
Not Compliant	7.4.1 – 7.4.7	These items deal with feedback that the system provides to the operator.	The current INCOMMANDS CDSC does not provide feedback to the operator after the operator provides an input to the system.	Major
7.5 SUPPORT IDENTIFICATION AND MANAGEMENT OF ESS FAULTS AND FAILURES				
Not Compliant	7.5.1 – 7.5.6	These items deal with the system providing the operator with visual identification of faults and failures.	The current INCOMMANDS CDSC does not show ESS faults and failures.	Major

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
8 CLASS-SPECIFIC ESS GUIDELINES				
8.2 DECISION MAKING AIDS				
8.2.1 ENSURE APPROPRIATE IMPLEMENTATION				
Experimental - Out of Scope	8.2.1.1	Decision making aids shall be used: for managing system complexity; for assisting operators in coping with information overload; for focusing the operator's attention; for assisting the operator in accomplishing time-consuming activities more quickly; when limited data results in uncertainty; for overcoming human limitations that are associated with uncertainty, the emotional components of decision-making, finite-memory capacity, and systematic and cognitive biases; and, for assisting the operator in allocating resources, managing detailed information, performing computations, and selecting and deciding among alternatives.	The performance measures, NASA-TLX workload measure, situation awareness questionnaire would need to be used, and the usability and utility questionnaires were used to assess if the INCOMMANDS CDSC assists the operator with these requirements.	TBD
8.2.2 SUPPORT DECISION MAKING STRATEGIES				
Not Compliant	8.2.2.1	The decision making aid shall support decision alternatives.	The current INCOMMANDS CDSC does not allow operators to select their choice of atomic action plans. The operator must use the atomic action plan generated by the system.	Major
Not Compliant	8.2.2.2	When more than one alternative is available, the decision making aid shall provide alternatives in a recommended prioritization scheme based on mission and task analysis.	The current INCOMMANDS CDSC does not provide alternative atomic action plans.	Major
Not Compliant	8.2.2.4	When the information used by a decision making	The current INCOMMANDS CDSC does	Major

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
		aid is derived or processed, the data from which it is derived shall be either visible or accessible for verification.	not show the atomic action plan data from which the information used by a decision making aid is derived.	
Experimental - Out of Scope	8.2.2.7	The support provided by the decision making aid shall be consistent with operator cognitive strategies and expectations (mental models). A mental model is an individual's understanding of the processes underlying system operation.	The performance measures would need to be used to assess if the INCOMMANDS CDSC is consistent with operator cognitive strategies and expectations.	TBD
Experimental - Out of Scope	8.2.2.9	The decision making aid shall minimize queries by the operators for information.	The performance measures and the usability and utility questionnaires will assess if the INCOMMANDS CDSC minimizes queries from operators for information.	Minor
8.2.3 KEEP OPERATORS IN CONTROL				
Not Compliant	8.2.3.2	The decision making aid shall not be able to veto operator actions leaving the operator without means to override or violate rules that govern the decision making aid unless there is not enough time for the operator to make a decision.	The current INCOMMANDS CDSC does not allow operators to veto or override the system-generated atomic action plans.	Major
Not Compliant	8.2.3.3	The operator shall be able to initiate (i.e., over-ride) the automation of tasks even when a task has been designated to be decision making aid-initiated.	The current INCOMMANDS CDSC does not allow operators to initiate the automation of tasks.	Major
Not Compliant	8.2.3.4	The decision making aid shall assist, rather than replace, human decision makers by providing data for making judgments rather than commands that the operator must execute.	The current INCOMMANDS CDSC does not allow operators to override the atomic action plans generated by the decision support system.	Major
Not Compliant	8.2.3.6	The decision making aid shall accept direction from the operators on which problem solving strategy to employ when alternative strategies are	The current INCOMMANDS CDSC does not allow operators to direct the decision making aid as to which problem-solving	Major

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
		available.	strategy to employ.	
Not Compliant	8.2.3.7	Automated tasks or functions shall not be able to jeopardize safety or make a difficult situation worse.	The current INCOMMANDS CDSC does not allow operators to override the atomic action plans and this could possibly make a difficult situation worse.	Major
Not Compliant	8.2.3.8	When an operator might need to operate in out-of-tolerance conditions, then a deliberate overriding action shall be possible.	The current INCOMMANDS CDSC does not have a deliberate overriding action that the operator can operate in out-of-tolerance conditions.	Major
8.2.4 MAXIMIZE OPERATOR SITUATION AWARENESS BY INCREASING SYSTEM TRANSPARENCY				
Not Compliant	8.2.4.1	Processed data shall be accessible.	The current INCOMMANDS CDSC does not allow the operator to access or see all processed data.	Major
Not Compliant	8.2.4.4	The decision aid shall give the operator access to procedural information used by the aid.	The current INCOMMANDS CDSC does not give the operator access to procedural information used by the aid.	Major
Not Compliant	8.2.4.5	When the decision making aid provides explanations to the operator, it shall supply a short explanation initially, with the ability to make available more detail at the operator's request, including access to process information or an explanation for the rules, knowledge-basis, and solutions used by the decision aid.	The current INCOMMANDS CDSC does not provide a short explanation and does not make available more detail at the operator's request.	Major
8.3 CONTROL AND ACTION AIDS				
8.3.1 KEEP OPERATORS 'IN-THE-LOOP'				
Not Compliant	8.3.1.2	The Control and Action Aid shall provide the operator with an appropriate range of control options that are flexible enough to accommodate	The current INCOMMANDS CDSC does not provide the operator with an appropriate range of control options that	Major

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
		the full range of operating conditions for which it was certified.	are flexible enough to accommodate the full range of operating conditions	
Not Compliant	8.3.1.3	To promote sufficient levels of operator situation awareness of the Control and Action Aid, the operator shall be given immediate feedback to command and control orders.	The current INCOMMANDS CDSC does provide the operator with immediate feedback to command and control orders.	Major
Not Compliant	8.3.1.4	Override and backup control alternatives shall be available for automated tasks that are critical to the integrity of the system or when lives depend on the system.	The current INCOMMANDS CDSC does not allow the operator to override and control alternatives for automated tasks that are critical to the integrity of the system or when lives depend on the system.	Major
Not Compliant	8.3.1.5	The operator shall be able to initiate and control the direction and pace of the tasks and/or functions of the Control and Action Aid until the point at which operator goals have been met	The current INCOMMANDS CDSC does allow the operator to initiate and control the direction and pace of the tasks and/or functions of the Control and Action Aid until the point at which operator goals have been met.	Major
Not Compliant	8.3.1.6	Information for backup or override capability shall be readily accessible.	The current INCOMMANDS CDSC does allow the operator to access information to either backup or override the capability of the system.	Major
Not Compliant	8.3.1.7	The Control and Action Aid shall be designed so that operators are involved in active control and monitoring rather than just passive monitors.	The current INCOMMANDS CDSC does not allow the operator to interact very much with the system.	Major
Not Compliant	8.3.1.8	Allow reversal of operator actions (e.g. 'undo' or 'cancel' function) and give clear indications how	The current INCOMMANDS CDSC does allow operators to undo or cancel functions.	Major

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
		reversal can be achieved.		

10 WINDOWS

10.2 SYSTEM WINDOWS

10.2.1 STATUS BAR

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Not Compliant	10.2.1.4	A digital clock shall be displayed to the right end of the status bar, showing the Date/Time Group.	There is no digital clock displayed on the right end of the status bar.	Minor
Not Compliant	10.2.1.5	An alert (and messages) indicator (to notify the operator that alerts are present) is displayed on the left end of the status bar.	There is no alert indicator on the left end of the status bar.	Minor
Not Compliant	10.2.1.6	The notification of an alert shall indicate the priority of the alert, if available.	There is no alert indicator on the left end of the status bar.	Minor
Not Compliant	10.2.1.7	The contents of an alert (and message) shall be displayed in an area dedicated for that purpose near and below the alert notification indicator.)	There is no alert indicator on the left end of the status bar.	Minor
Not Compliant	10.2.1.8	System alerts shall be identified distinctly from operational alerts in the alert notification area.	There is no alert indicator on the left end of the status bar.	Minor

10.2.2 OPTIONAL DISPLAY OF CLASSIFICATION

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Out of Scope	10.2.2.1 – 10.2.2.11	This section covers how classified windows shall be displayed.	The current INCOMMANDS CDSC does not display classified windows.	Minor

10.3 PRIMARY WINDOWS

10.3.4 FIXED WINDOWS

10.3.4.1 FIXED WINDOWS CHARACTERISTICS

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Not Compliant	10.3.4.1.2	Fixed windows shall be automatically loaded upon system initialization and cannot be closed or minimized.	The fixed windows currently have a minimize/maximize/restore control.	Minor

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Not Compliant	10.3.4.1.3	Fixed windows cannot be re-sized or re-located by the user.	The fixed windows currently have a re-size control.	Minor
Not Compliant	10.3.4.1.6	The title bar and sizing frame are removed from fixed windows since they cannot be closed, moved or sized.	The title bar and sizing frame have not been removed from the fixed window.	Minor

11 WINDOW DESIGN GUIDANCE

11.2 ARRANGING INFORMATION TO MATCH USER ACTIONS

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Not Compliant	11.2.1	A window shall be designed so users can manipulate objects in ways that support task performance.	The current INCOMMANDS CDSC does not allow operators to manipulate objects in ways that support task performance.	Major

12 WINDOW NAVIGATION AND SELECTION

12.1 WINDOW NAVIGATION

12.1.3 ASSIGNING FOCUS TO A WINDOW WITH A POINTING DEVICE AND THE KEYBOARD

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Not Compliant	12.1.3.1	Users assign focus by moving the pointer into a window and clicking the S button.	The current INCOMMANDS CDSC does not allow operators to click the S button to assign focus.	Minor
Not Compliant	12.1.3.2	If users click in an empty window area, the window frame shall highlight and the window shall be raised to the front.	When clicked on, the windows frame on the current INCOMMANDS CDSC does not highlight and the window does not raise to the front.	Minor
Not Compliant	12.1.3.3	If users click in the title bar, the frame shall highlight and the window shall be raised to the front and shall receive input focus.	When the title bar is clicked on the current INCOMMANDS CDSC, the frame is not highlighted and raised to the front.	Minor
Not Compliant	12.1.3.4	If users click on an object within a window, the window frame shall highlight, the window shall be raised, and an object shall be selected.	When an object is clicked on within a window on the current INCOMMANDS CDSC, the window frame does not highlight and raise.	Minor

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Not Compliant	12.1.3.5	A window is raised by clicking anywhere in the window. The window is then moved to the top of the window hierarchy (except for any toolbars or pallets associated with the window being raised) and is given input focus. A window may also be raised by selecting it from the open window menu.	The windows on the current INCOMMANDS CDSC do not raise when clicked on.	Minor
Not Compliant	12.1.3.6	<Alt> + <Tab> and <Alt> + <Shift> + <Tab> shall move the focus forward and backward through window families (i.e., primary windows and window icons).	The Current INCOMMANDS CDSC does not allow operators to input these commands.	Minor
Not Compliant	12.1.3.7	<Alt> + <F6> and <Alt> + <Shift> + <F6> move the focus forward and backward through windows in a family.	The Current INCOMMANDS CDSC does not allow operators to input these commands.	Minor
12.2 NAVIGATION WITHIN WINDOWS				
12.2.1 POINTING DEVICE NAVIGATION FOR CONTROLS				
Not Compliant	12.2.1.1	Placing the pointer on a control and clicking the S button shall move the location cursor to the object and shall give the object focus.	The current INCOMMANDS CDSC does not allow operators to input this command.	Minor
Not Compliant	12.2.1.2	Pressing the <Ctrl> key and clicking the S button on an object shall select the object and keep the current object selected.	The current INCOMMANDS CDSC does not allow operators to input this command.	Minor
Not Compliant	12.2.1.3	Autoscrolling shall be available when the pointer is on a scrollable control such as a text block or a list.	The current INCOMMANDS CDSC does not allow operators to input this command.	Minor
Not Compliant	12.2.1.4	The means shall be provided to readily move the cursor to the head or the foot (end) of a file.	The current INCOMMANDS CDSC does not allow operators to input this command.	Minor
12.2.2 KEYBOARD NAVIGATION FOR CONTROLS				
Not Compliant	12.2.1 – 12.2.2.15		The current INCOMMANDS CDSC does not allow operators to input any of the Keyboard Navigations	Minor

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
12.2.3 KEYBOARD NAVIGATION FOR GRAPHIC OBJECTS				
Not Compliant	12.2.3.1	Navigation among graphics objects shall use the same key bindings as navigation among controls.	The current INCOMMANDS CDSC does not allow operators to input these commands.	Minor
12.3 OBJECT SELECTION				
12.3.1 POINTING DEVICE SELECTION METHODS				
Not Compliant	12.3.1.2	To select multiple objects, click the S button on objects one at a time while holding down the <Ctrl> key. The objects are highlighted and selected. (TBM, MSWUE).	The current INCOMMANDS CDSC does not allow operators to input this command.	Minor
Not Compliant	12.3.1.3	Where text has been specified to become the subject of control entries (e.g., for underlining, bolding, moving, copying, or deleting), the affected segment of text shall be highlighted to indicate its boundaries.	The current INCOMMANDS CDSC does not allow operators to input control entries.	Minor
Not Compliant	12.3.1.4	To select a range of contiguous objects, the pointer shall be positioned on the first object in the range to be selected, and then the S button shall be selected to set the anchor for the range. Any other object that was selected shall be deselected. The pointer shall be dragged until it is on the last object in the range, and the S button shall be released to complete the selection.	The current INCOMMANDS CDSC does not allow operators to select a range of contiguous objects.	Minor
Not Compliant	12.3.1.5	To extend a range selection the user shall position the pointer on the object that shall be the last one in the selection, and hold down the <Shift> key while clicking the S button on the pointing device. The objects in the revised selection range (defined from the original anchor to the current pointer position in	The current INCOMMANDS CDSC does not allow operators to carry out this operation.	Minor

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
		one-dimensional collections, and defined by the diagonal from the anchor to the current pointer position in two dimensional collections) shall be reselected, and any elements removed from the selection shall return to normal appearance.		
Not Compliant	12.3.1.6	To add or remove a non-contiguous object to or from a range selection, the pointer shall be positioned on the object, and then the <Ctrl> key shall be held down while clicking the S button on the pointing device. If previously unselected, the object shall be selected and highlighted. If previously selected, the object is deselected and shall return to a normal appearance. The other elements in the selection shall remain highlighted.	The current INCOMMANDS CDSC does not allow operators to select a range of contiguous objects.	Minor
Not Compliant	12.3.1.7	A bounding box shall appear when dragging the pointer over elements in a two dimensional collection.	A bounding box does not appear when dragging the pointer over elements in a two dimensional collection.	Minor
12.3.2 KEYBOARD SELECTION METHODS				
Not Compliant	12.3.2.1 – 12.3.2.10		The current INCOMMANDS CDSC does not allow operators to input any of the Keyboard Selection Methods	Minor
12.3.3 OTHER TYPES OF SELECTION				
Not Compliant	12.3.3.1 – 12.3.3.6		The current INCOMMANDS CDSC does not allow operators to select any other types of inputs from the keyboard	Minor
12.5 INTERACTIVE CONTROL				
12.5.1 OBJECT-ACTION SELECTION				
Not Compliant	12.5.1.1	Users shall first select an object, and then they shall select an action to perform on that object.	The current INCOMMANDS CDSC does not allow operators to perform actions on	Major

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
			selected objects.	
12.5.2 USER CONTROL OF INTERACTION				
Not Compliant	12.5.2.1	Applications shall execute an action only in response to explicit user input.	The current INCOMMANDS CDSC does not allow operators to input commands.	Major
Not Compliant	12.5.2.2	Users may take actions that will interrupt or terminate a process.	The current INCOMMANDS CDSC does not allow operators to terminate processes.	Major
12.5.3 IMMEDIATE FEEDBACK				
Not Compliant	12.5.3.1	Control feedback responses to correct user input shall consist of changes in state or value of those display elements which are being controlled and shall be presented in an expected and logically natural form.	The current INCOMMANDS CDSC does not provide control feedback responses.	Major
Not Compliant	12.5.3.2	When users take an action, there shall be an immediate and visible response to the action.	The current INCOMMANDS CDSC does not accept operator inputs so therefore, there are no immediate and visible responses to the action.	Major
Not Compliant	12.5.3.3	A visible response shall occur even if the result cannot be displayed immediately.	The current INCOMMANDS CDSC does not accept operator inputs so therefore, no visible responses is available.	Major
Not Compliant	12.5.3.4	An application shall provide visual cues that indicate when it can accept input, when it is temporarily unavailable, and when it is unavailable during extended processing.	The current INCOMMANDS CDSC does not accept operator inputs so no visual cues that indicate when the system can accept input, when it is temporarily unavailable, and when it is unavailable during extended processing are available.	Major
Not Compliant	12.5.3.6	If an operation requires several actions, users shall be prompted with the actions to take.	The current INCOMMANDS CDSC does not provide operators with prompts for actions that are to be taken.	Major
Not Compliant	12.5.3.7	Applications shall ignore user actions made during	The current INCOMMANDS CDSC does	Major

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
		periods when input cannot be accepted.	not accept operator inputs so the system cannot ignore actions made during periods when input cannot be accepted.	
Not Compliant	12.5.3.8	The pointing device and/or the keyboard shall be disabled when input may be destructive.	The current INCOMMANDS CDSC does not disable the keyboard and/or pointing device when input may be destructive.	Major
Not Compliant	12.5.3.9	Although an application shall not allow users to override disabling, users shall be able to stop a process if desired (e.g., by selecting a cancel, or equivalent, push button).	The current INCOMMANDS CDSC does not allow operators to stop processes.	Major
Not Compliant	12.5.3.10	The current value of any parameter or variable with which the user is interacting shall be displayed.	The current INCOMMANDS CDSC does not display the current value of any parameter or variable.	Major
12.5.4 SYSTEM RESPONSE TIME				
Not Compliant	12.5.4.1 – 12.5.4.22		The current INCOMMANDS CDSC has limited capability to allow operator to interact with the system	Major
12.5.5 ERROR DETECTION				
Not Compliant	12.5.5.1 – 12.5.4.11		The current INCOMMANDS CDSC does not provide any error messages to operators.	Major
12.5.6 UNDO CAPABILITY				
Not Compliant	12.5.6.1 – 12.5.6.7		The current INCOMMANDS CDSC does not allow the operator to undo any actions.	Major
13 CONTROLS				
13.1 CONTROL CHARACTERISTICS				
Not Compliant	13.1.6	Controls that are temporarily unavailable shall be dimmed and shall not be available for selection.	The current INCOMMANDS CDSC does dim temporarily unavailable controls and	Major

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
		make them unavailable for selection.		
Not Compliant	13.1.7	Controls that are never available to users shall not appear in a window.	The current INCOMMANDS CDSC shows all of the controls to the operator even though some are not yet functioning.	Major

13.5 PUSH BUTT0NS

13.5.5 ACTIVATING A PUSH BUTTON

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Not Compliant	13.5.5.2	The <Space> key (and <Select> if available) shall select a push button from the keyboard when the location cursor is on a push button.	The current INCOMMANDS CDSC does not allow the operator to input this action.	Minor
Not Compliant	13.5.5.3	When a push button is selected, it shall highlight and the action it represents shall be executed.	When a push button is selected, it does not highlight.	Minor

13.6 TOOLBARS

13.6.3 TOOLBAR WINDOWS

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Not Compliant	13.6.3.1	All toolbars shall be able to float by selecting any region inside the toolbar and moving it to another display location	The toolbars do not float and cannot be moved to another display location.	Minor
Not Compliant	13.6.3.2	The floating toolbar window shall then be able to be closed, sized, or moved to any other display location like a normal window	The toolbar does not float.	Minor
Not Compliant	13.6.3.5	An application action icon palette or toolbar shall be able to be repositioned or removed from the window if desired by the user	The tools cannot be repositioned or moved.	Minor

17 DATA DISPLAY AND ENTRY

17.3 DATA DISPLAY

17.3.7 NUMBERS

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Not Compliant	17.3.7.1	When displaying numbers the number zero shall have a slash through it so it is not confused with a capital "O". The letter L and the digit 1 shall also	The number zero on the INCOMMANDS CDSC does not have a slash through it.	Minor

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
		be displayed so as not to be confused with each other		
17.3.8 UNITS OF MEASUREMENT				
Not Compliant	17.3.8.5	The system shall allow users to input data in a familiar unit of measure.	Operators cannot input any information into the current INCOMMANDS CDSC.	Minor
17.3.13 DATA QUERY				
Not Compliant	17.3.13.2	The language shall allow the users to specify the data to retrieve, then display and manipulate it.	Operators cannot retrieve, display or manipulate data.	Major
Not Compliant	17.3.13.3	Users shall be provided the capability to request data without having to tell the system how to find it.	Operators cannot retrieve data from the system.	Major
Not Compliant	17.3.13.4	Queries shall use operationally meaningful terminology and do not reflect how the data are stored.	Operators cannot query the system for data.	Major
Not Compliant	17.3.13.5	Users may construct simple and complex queries, create predefined queries and save, retrieve, and execute these queries.	Operators cannot query the system for data.	Major
Not Compliant	17.3.13.6	The language shall permit alternate forms of the same query using natural language.	Operators cannot query the system for data.	Major
Not Compliant	17.3.13.7	Users shall be prompted to confirm a query if data retrieval time will be excessive.	Operators cannot query the system for data.	Major
18 SPECIAL FUNCTIONS AND FORMATS				
18.2 DATE/TIME AND LATITUDE/LONGITUDE				
Not Compliant	18.2.1	All dates shall be presented to and supplied by the operator in the DD MMM YY (10 MAY 68) format. The characters of the month shall be capitalized. The spaces between day and month and month and year may be omitted. If the day or year	Dates are not presented in the DD MMM YY format.	Minor

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
		is a single digit it must be preceded by a zero. The notation 01JAN00 would mean January 1, 2000.		
Not Compliant	18.2.2	Time shall be presented to and supplied by the operator in the HH:MM:SSZ (09:38:30Z) format. HH is the hour in a 24-hour day, MM is the minute with a leading zero if necessary, and SS is the second with the leading zero if necessary. Z is the time zone with Zulu time as the default. The seconds are optional. All colons are required and the Zulu (Z) shall be capitalized.	Times is not presented in the HH:MM:SSZ format.	Minor
Not Compliant	18.2.3	The display shall include Zulu time and local time; Zulu time shall be presented above local time.	The display does not include Zulu time.	Minor
Not Compliant	18.2.5	If the operator must know the time in multiple time zones, the application shall provide a separate time for each zone or provide the operator the ability to change the time zone displayed	Time in multiple time zones is not displayed.	Minor
Not Compliant	18. 2.6	A date time group shall be presented to and supplied by the operator in the DD HH:MM:SSZ MMM YY format (seconds are optional) where DD is the day with the leading zero if necessary, HH is the hour with a leading zero if necessary, MM is the minute with a leading zero if necessary, SS is the second with a leading zero if necessary, and Z is the time zone with Zulu as the default with MMM as the abbreviated month and YY is the last two digits of the year. All colons and spaces are required	The date time group is not presented in the DD HH:MM:SSZ MMM YY format.	Minor

22 COLOUR

22.2 COLOUR SETS

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Not Compliant	22.2.5	Users shall be able to select from between colour sets: One set shall be provided for each of the lighting conditions in the operations room (e.g., normal operations room lighting and dark adaptation lighting.	Operators do not have the option of selecting colour sets.	Minor
Not Compliant	22.2.6	The operator shall have the options to select between colour sets for each applicable lighting condition but shall not otherwise adjust the individual colours in the display.	Operators do not have the option of selecting colour sets.	Minor

22.3 SPECIFIC COLOUR USE

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Not Compliant	22.3.9	Symbology shall be colour coded using conventions including the following unless superseded by NTDS or other explicitly specified symbology conventions: ◆ hostile: red (or magenta) ◆ friend: blue (or cyan) ◆ unknown: yellow ◆ neutral: green.	The symbology colour coding on the Threat Evaluation View does not follow NTDS conventions.	Major
Not Compliant	22.3.10	The Halifax Class CCS specifies white symbology to denote computer-identified contacts. The CCS specification shall be followed unless superseded by specified symbology conventions.	Computer-identified contacts on the Threat Evaluation View are not depicted with white symbology.	Major

22.4 COLOUR GUIDELINES

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
Not Compliant	22.4.1	Colour coding for symbology shall be consistent with NTDS conventions, with the caveat as described in Paragraph and repeated in the UCA note below. A sample of NTDS conventions is	The colour coding for symbology on the Threat Evaluation View is not consistent with NTDS conventions.	Major

Compliance	Paragraph	INCOMMANDS HF Design and Evaluation Guide	INCOMMANDS CDSC	Severity Rating
		provided in *Appendix III*: *NTDS Symbology.*		

Annex B Informed Voluntary Consent Form

Research Project Title: Evaluation of the INCOMMANDS Prototype

Principal Investigator: Kevin Baker (CAE Professional Services, Canada)

Co-Investigator: Lisa Hagen (CAE Professional Services, Canada)

DRDC Co-Investigators: Sharon McFadden and Wenbi Wang, DRDC Toronto

I, _____, hereby volunteer to participate as a subject in the study, "INCOMMANDS". I have read the information material, and have had the opportunity to ask questions of the study Investigators. All of my questions concerning this study have been fully answered to my satisfaction. However, I may obtain additional information about the research project and have any questions about this study answered by contacting Kevin Baker (613-247-0342 x208) or Lisa Hagen (613-247-0342 x245).

I am aware that I will participate in a training session to learn how to use the system. Once I am proficient and comfortable with the system, I will complete a 15-minute practice scenario. After completion of the practice scenario the experimental manager or the SME on site will ask me if I know how to and I am comfortable with performing a series of tasks that would be required during testing bearing in mind that the experimental staff will not provide assistance to me during the experimental sessions. Once I indicate that they I am able to perform these tasks, I will be asked to complete a consent form and to provide some professional and personal background information (e.g., number of years of experience as an operator). I will then complete the 20-minute usability and utility trial and then I will fill out a questionnaire that asks me to rate various aspects of my situational awareness. Following completion of the questionnaire, I will be asked to complete a usability and a utility questionnaire regarding the realism and usability of the scenario and the efficacy of the operator-machine interface (e.g., the physical and functional displays). Following completion of the usability and the utility questionnaires, I will be debriefed by the experimental staff.

I have been told that this experiment offers minimal risk to my health and well-being. There is a low risk of eye fatigue or eyestrain, as would be associated with doing any visually intensive task (e.g. web searching, word processing) on computer display for the period of time used in the test sessions. This may manifest itself as eye discomfort, dry or itchy eyes, or mild headache. However, the duration of exposure to the visual displays will be short and I will have a 5-minute break between sessions on a single day to mitigate this risk. I will be encouraged to inform experimenters if I experience any discomfort or eyestrain, or if I have any problems during the investigation.

I consider the aforementioned tasks and risks acceptable and understand that my participation in this study may involve risks that are currently unforeseen by the investigators.

[For Canadian Forces (CF) members only] – I understand that I am considered to be on duty for disciplinary, administrative and Pension Act purposes during my participation in this study. With that said, this duty status has no effect on my right to withdraw from the trial at any time I wish and it is clear that no action will be taken against me for exercising this right. As well, in the unlikely event that my participation in this study results in a medical condition rendering me unfit for service, I may be released from the CF and my military benefits apply.

I agree to provide responses to questions that are to the best of my knowledge truthful and complete. I have been advised that the experimental data concerning me will be treated as confidential and not revealed to anyone other than the investigators without my consent except as data unidentified as to source. I understand that my name will not be identified or attached in any manner to any publication arising from this study. Moreover, should it be required, I allow the experimental data to be reviewed by an internal or external audit committee with the understanding that any summary information resulting from such a review will not identify me personally. I am aware that there will not be any on-site medical coverage during the experiment.

I understand that I am free to refuse to participate and may withdraw my consent without prejudice or hard feelings at any time. Should I withdraw my consent, my participation as a participant will end immediately.

I have informed the Investigator that I am currently a subject in the following other DRDC research project(s):_____
(cite Protocol Number(s) and associated Principal Investigator(s)), and that I am participating as a subject in the following reach project(s) at an institution other than DRDC: _____ (cite name(s) of institution(s)).

I understand that by signing this consent I have not waived any legal rights I may have as a result of any harm to me occasioned by my participation in this research project beyond the risks I have assumed.

Volunteer's Name: _____ Signature: _____

Date: _____

Name of Witness to Signature: _____

Signature: _____ Date: _____

Section Head/Commanding Officer's Signature (see Notes below)

_____

CO's Unit: _____

Principal Investigator: _____ Signature: _____

Date: _____

Notes:

For Military personnel on permanent strength of CFEME: Approval in principle by Commanding Officer is given in Memorandum 3700-1 (CO CFEME), 18 Aug 94; however members must still obtain their Section Head's signature designating approval to participate in this particular research project

For other military personnel: All other military personnel must obtain their Commanding Officer's signature designating approval to participate in this research project.

FOR SUBJECT ENQUIRY IF REQUIRED:

Should I have any questions or concerns regarding this project before, during, or after participation, I understand that I am encouraged to contact CAE Professional Services, 300-1135 Innovation Drive, Ottawa, ON, K2K 3G7) or Defense R&D Canada Toronto (PO Box 2000, 1133 Sheppard Avenue West, Toronto, Ontario, Canada, M3M 3B9). This contact can be made by surface mail at these addresses, or in person, by phone, or by email to any of the numbers and addresses listed below:

Principal Investigator:

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Chair, DRDC Human Research Ethics Committee (HREC):

Dr. Jack Landolt, 416-635-2120, Jack.Landolt@drdc-rddc.gc.ca

I understand that I will be given a copy of this consent form so that I may contact any of the above-mentioned individuals at some time in the future should that be required.

Annex C   Usability Questionnaire–TE Functional View

Instructions: Place a mark in the box that most closely reflects your answer.

1. The size of the threat list is suitable.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

2. The size of the swimlanes is suitable.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

3. The number of swimlanes is suitable.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

4. I found it easy to toggle the x-axis scale between range and time.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

5. I found it easy to expand/reduce the x-axis scale.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

6. Titles and labels are clear.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

7. The colours used on the screen make sense to me.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

8. The size of the lettering on the screen is easy to read.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

9. I always know where the cursor is on the Threat Evaluation Functional View display.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

10. The cursor travels at an appropriate speed on the Threat Evaluation Functional View display.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

11. I can find important items quickly.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

12. I found the Threat Evaluation Functional View easy to use.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

13. I needed to learn a lot about the Threat Evaluation Functional View before I could use it.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

14. I felt comfortable using the Threat Evaluation system.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

15. The Threat Evaluation Functional View has all the functions and capabilities I expect it to have.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

16. The organization of information on the Threat Evaluation Functional View screen was clear.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

17. The information provided by the Threat Evaluation Functional View was easy to understand.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

18. I knew what the Threat Evaluation Functional View system was doing at all times.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

19. In general, the system provides information users will use.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

20. It was simple to use this system.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

21. Overall, I am satisfied with this system.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

Overall comments and suggestions:

_____
_____
_____
_____
_____
_____
_____
_____
_____.

Annex D   Usability Questionnaire–CPM Functional View

Instructions: Place a mark in the box that most closely reflects your answer.

1.   The size of the local engagement plan is suitable.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

2.   The size of the atomic actions is suitable.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

3.   I found it easy to expand/reduce the x-axis scale.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

4.   Titles and labels are clear.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

5.   The colours used on the screen make sense to me.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

6. The size of the lettering on the screen is easy to read.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

7. I always know where the cursor is on the Combat Power Functional View display.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

8. The cursor travels at an appropriate speed on the Combat Power Functional View display.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

9. I can find important items quickly.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

10. I found the Combat Power Functional View easy to use.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

11. I needed to learn a lot about the Combat Power Functional View before I could use it.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

12. I felt comfortable using the Combat Power system.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

13. The Combat Power Functional View has all the functions and capabilities I expect it to have.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

14. The organization of information on the Combat Power Functional View screen was clear.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

15. The information provided by the Combat Power Functional View was easy to understand.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

16. I knew what the Combat Power Functional View system was doing at all times.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

17. In general, the system provides information users will use.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

18. It was simple to use this system.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

19. Overall, I am satisfied with this system.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

20. Overall comments and suggestions:

_____
_____
_____
_____
_____
_____
.

Annex E   Utility Questionnaire

Instructions: Place a mark in the box that most closely reflects your answer.

1. Overall, the use of the Threat Evaluation View improved my ability to make decisions with respect to the goals and processes pertaining to the assessment of threats in the environment.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

2. The Threat Evaluation View provided me with a more comprehensive assessment of all threats in the environment.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

3. The Threat Evaluation View allowed me to form an accurate mental picture of my environment.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

4. The Threat Evaluation View always made it clear where the targets were in relationship to the ownship.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

5. It was always clear when a target made a category jump (e.g., from a mid-level threat to a high-level threat).

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

6. The Threat Evaluation View helped me to avoid "tunneling" on the highest priority threat.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

7. It was useful having the ability to switch between a time and a range scale (nautical miles) on the Threat Evaluation View.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

8. The information in the roll-over menu helped me to quickly gather information about the threats in the environment.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

9. The interface on the Threat Evaluation View allowed me to easily view all of the information required to evaluate all the threats in my environment.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

10. I found that the location of all the information on the Threat Evaluation View interface allowed me to quickly and easily evaluate all the threats in my environment.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

11. If you could make changes to the interface on the Threat Evaluation View, what changes would you make?_____

_____
_____
_____
_____
_____

12. The Threat Evaluation View decreased my overall workload.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

13. The Threat Evaluation View would decrease my overall workload more in a high-workload situation relative to a low-workload situation.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

14. The Threat Evaluation View increased my overall situation awareness.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

15. The Threat Evaluation View would increase my overall situation awareness more in a high-workload situation relative to a low-workload situation.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

16. The presence of the Threat Evaluation View will not interfere with the flow of communication in the operations room.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

17. I would feel comfortable using the Threat Evaluation View under time pressure.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

18. Overall, the Threat Evaluation View is a valuable tool for evaluating threats in the environment.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

19. Overall, the Threat Evaluation View will make the operator's job easier.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

20. Overall, the use of the Combat Power Functional View would improve my ability to make decisions with respect to the management of combat power.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

21. Overall, the use of the Combat Power Functional View would improve my ability to make decisions with respect to the application of combat power.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

22. The Combat Power Functional View would improve my ability generate an 'optimum' global engagement plan.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

23. During the execution of a combat power plan, the Combat Power Functional View would help me to assess the outcome of an engagement.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

24. The interface on the Combat Power Functional View allowed me to easily view all of the information required to evaluate the engagement plan present on the display.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

25. The interface on the Combat Power Functional View allowed me to easily view all of the information required to evaluate whether the presented engagement plan would be a successful plan.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

26. I found that the location of all the information on the Combat Power Functional View interface allowed me to quickly and easily evaluate the engagement plan presented on the display.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

27. If you could make changes to the interface on the Combat Power Functional View, what changes would you make?_____

_____
_____
_____
_____
_____

28. The Combat Power Functional View would decrease my overload workload.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

29. The Combat Power Functional View would decrease my overall workload more in a high-workload situation relative to the low-workload situation.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

30. The Combat Power Functional View would increase my overall situation awareness.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

31. The Combat Power Functional View would increase my overall situation awareness more in the high-workload situation relative to the low-workload situation.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

32. The presence of the Combat Power Functional View would not interfere with the flow of communication in the operations room.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

33. I would feel comfortable using the Combat Power Functional View under time pressure.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

34. Overall, the Combat Power Functional View is a valuable tool for managing and applying combat power.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

35. Overall, both the Threat Evaluation View and the Combat Power Functional View would decrease my workload.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

36. Overall, both the Threat Evaluation View and the Combat Power Functional View would increase my situation awareness.

☹ Strongly Disagree	Disagree	Border	Agree	☺ Strongly Agree	Suggested Improvements

37. Should additional capabilities be added?   Yes_____   No_____

If yes, please explain_____

_____
_____
_____
_____

38. Should any of the capabilities be eliminated or changed?   Yes_____ No_____

If yes, please explain_____

_____
_____
_____
_____

39. How satisfactory was the Threat Evaluation View and the Combat Power Functional View for meeting task and time demands?

☹ Very Unsatisfactory	Unsatisfactory	Border	Satisfactory	☺ Very Satisfactory

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40. Overall comments and suggestions:

_____
_____
_____
_____
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_____.

Annex F   Proposed Experimental Plan

F.1   General

As previously mentioned, an experiment was initially proposed to investigate the causal relationships between the INCOMMANDS CSDC and a serious of factors including workload, situation awareness, and task performance. However, it was not possible to carry out the experiment within the time frame of the TDP. The experimental plan created in anticipation of this validation exercise has been included in this annex in the event that it can be performed at a later date.

F.2   Objectives

The objective of the investigation outlined below is to collect data to be used in the development, validation and implementation of decision support concepts to support the conduct of threat evaluation (TE) and combat power management (CPM) functions by Canadian Forces (CF) personnel on-board a HALIFAX Class frigate.

The proposed experiment would be a laboratory based study requiring participants (experience operators) to perform activities and make decisions to support goals pertaining to threat evaluation and combat power management. Situational awareness, workload, operator trust, and task performance measures would be collected during the experiment.

F.3   Measures of Performance

For this study several different measures for assessing performance are proposed. They include but are not necessarily limited to:

1.   Situation awareness

2.   Workload

3.   Task relevant performance

4.   Trust

Each of these measures is discussed below in the following sections.

F.3.1   Situation Awareness (SA)

It is proposed to measure situation awareness using one or more of the following techniques:

1.   **Situation Awareness Rating Technique (SART):** Participants complete the SART after the completion of each experimental trial. SART provides a validated and practical subjective rating tool for the measurement of SA, based on personal construct dimensions associated

with SA. The structure of the construct dimensions has been interpreted as comprising three related conceptual groups, which form the principal dimensions of SART, namely:

a. Demand for attentional resources or D (complexity, variability, instability);

b. Supply of attentional resources or S (arousal, concentration, division of attention, spare mental capacity);

c. Understanding of the situation or U (information quality, information quantity, familiarity).

The most commonly-used version of SART is the 14-dimension version (see Figure 18). Instead of numeric Likert-scales, a graphical display of the rating scales is utilized, where the length of line from the left hand side of the scale to the operator's mark (in millimetres) represents a respective rating score for one item. The possible range is between 0 ("low") and 50 ("high"). Questions 1, 2, 3 and 4 are averaged to give a D score (Demand). Questions 5, 6, 7, 8 and 9 are averaged to give an S score (Supply). Questions 10, 11, 12 and 13 are averaged to give a U score (Understanding). Situation awareness in total (T) is then calculated by U - (D - S). Finally, Question 14 gives the operator's confidence in their ratings of the above.

2. **Change Blindness:** This measures the operator's ability to notice changes (i.e., changed entities) on their displays. It is anticipated that operators will often fail to notice these changes; however, in cases where the changes are noticed, the time required to notice them should be measured. Change blindness is designed to complement the SART measure by providing an on-line metric of the operator's SA for abrupt changes to their physical displays.

1. Demand on Attentional Resources (capacity) How demanding were the tasks on your attentional resources? Were they excessively demanding (high) or minimally demanding (low)?	*low* ———————————————— *high*
2. Instability of Session How changeable was the session (situation)? Was it highly unstable and likely to change suddenly (high), or was it very stable and straight forward (low)?	*low* ———————————————— *high*
3. Complexity of Session How complicated was the session? Was it complex with many interrelated components (high) or was it simple and straightforward (low)?	*low* ———————————————— *high*
4. Variability of Session How many variables were changing in the session? Were there a large number of factors varying (high) or were there very few variables changing (low)?	*low* ———————————————— *high*
5. Supply of Attentional Resources (capacity) How much of your attentional resources were you supplying to the session? Were you making the greatest possible effort (high) or giving very little attention (low)?	*low* ———————————————— *high*
6. Arousal How aroused were you in the session? Were you alert and ready for activity (high) or did you have a low degree of alertness (low)?	*low* ———————————————— *high*
7. Concentration of Attention How much were you concentrating on the session? Were you bringing all your thoughts to bear (high) or was your attention elsewhere (low)?	*low* ———————————————— *high*
8. Division of Attention How much was your attention divided in the session? Were you concentrating on many aspects of the situation (high) or focussed on only one (low)?	*low* ———————————————— *high*
9. Spare Mental Capacity How much mental capacity did you have to spare in this session? Did you have sufficient to attend to many new variables (high) or nothing to spare at all (low)?	*low* ———————————————— *high*
10. Understanding of Session How well did you understand the session? Did you understand almost everything (high) or virtually nothing (low)?	*low* ———————————————— *high*
11. Information Quantity How much information did you gain from your environment (inside and outside the cockpit)? Did you receive and understand a great deal of knowledge (high) or very little (low)?	*low* ———————————————— *high*
12. Information Quality How good was the information you had gained from your environment (inside and outside the cockpit)? Was the knowledge communicated very useful (high) or was it of very little use (low)?	*low* ———————————————— *high*
13. Familiarity with Session How familiar were you with the session? Did you have a great deal of relevant experience (high) or was it a new session (low)?	*low* ———————————————— *high*
14. Confidence in Ratings How confident are you of the ratings you have just made? Are you very confident (high), or not very confident (low)?	*low* ———————————————— *high*

Figure 18: Situation Awareness Rating Technique Input Form

F.3.2   Workload

It is proposed to measures workload using a modified version of the NASA Task Load Index (TLX) (see Figure 19). In addition to the six workload subscales used in the standard NASA TLX, the version of the TLX shown here also includes a seventh subscale that measures the operator's overall workload. Specifically, operators would be asked to rate their workload for:

1. Mental Demand

2. Physical Demand

3. Temporal Demand

4. Frustration Level

5. Effort

6. Performance

7. Overall

Operators indicate their workload by placing an "X" on a horizontal scale where the leftmost marker represents 0% (i.e., very low) workload and the rightmost marker represents 100% (i.e., very high) workload. Each 10% interval is demarcated on the scale. If an "X" is placed in between two 10% demarcations (e.g., between 50% and 60%), then workload will be measured to the nearest 5% (i.e., 55%). Each of the seven workload subscales listed above will be rated separately. That is, operators will place an "X" on the Mental Demand scale (where 0% represents no mental demand and 100% represents very high mental demand). Then, they will place an "X' on the Physical Demand scale. This process will continue until they have placed an "X" on all seven subscales.

Instructions: Please respond to each statement below by selecting the most appropriate rating response based on your experiences today.

1. **Mental Demand:** How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching)? Was the task easy **or** demanding, simple **or** complex, exacting **or** forgiving?

LOW |_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|HIGH
     0%   10%   20%   30%   40%   50%   60%   70%   80%   90%   100%
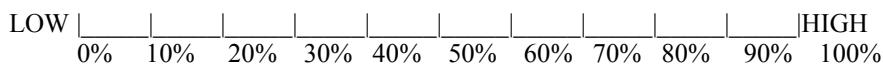
2. **Temporal Demand:** How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely **or** rapid and frantic?

LOW |_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|HIGH
     0%   10%   20%   30%   40%   50%   60%   70%   80%   90%   100%
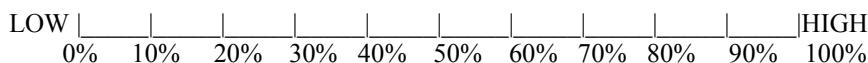
3. **Effort:** How hard did you have to work (mentally and physically) to accomplish your level of performance?

LOW |_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|HIGH
     0%   10%   20%   30%   40%   50%   60%   70%   80%   90%   100%
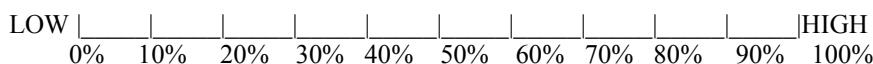
4. **Frustration Level:** How insecure, discouraged, irritated, stressed, and annoyed **versus** secure, gratified, content, relaxed and complacent did you feel during the task?

LOW |_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|HIGH
     0%   10%   20%   30%   40%   50%   60%   70%   80%   90%   100%
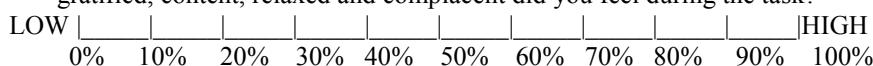
5. **Performance:** How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?

LOW |_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|HIGH
     0%   10%   20%   30%   40%   50%   60%   70%   80%   90%   100%
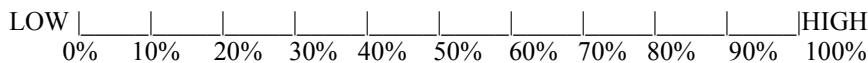
6. **Overall Workload:** Overall, how demanding did you find the task?

LOW |_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|HIGH
     0%   10%   20%   30%   40%   50%   60%   70%   80%   90%   100%
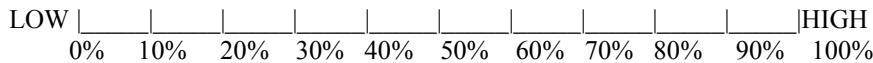
Figure 19: Proposed Task Load Index (TLX)

F.3.3   Task-Relevant Performance

Approaches for measurement of task-relevant performance include:

1. **Critical Task Sequence (CTS) completion time:** CTSs must be defined a priori by SMEs and the experimental team and will represent a critical mission task that the operator must complete quickly and accurately in order to ensure ship survivability. These CTSs should also

be chosen based on their likelihood of being differentially affected by the independent variables or experimental conditions. Further these CTSs must have objective and easily observable start and end points that can be precisely captured by either the audio/video equipment or the scenario generation tools (e.g., button press responses, verbal commands). The time difference between the start and end points of each CTS should be calculated so as to determine the length of time required to complete the tasks.

2. **Percentage of CTS shedding:** The number of incomplete CTSs relative to the total number of CTSs can also be measured to compliment the CTS completion time data. It is standard practice to measure error rates when completion time (reaction time) for a task is a dependent variable. The rationale for doing so is to capture the fact that some operators will modify their response strategy under high workload conditions where they trade-off accuracy for speed. That is, they selectively respond to only a few tasks very effectively (i.e., low completion times and error rates), but at the cost of making errors on (or ignoring) other tasks. In the context of this experiment, the percentage of CTS shedding would effectively capture the strategy described above. That is, some operators may adopt a strategy where they only complete a select few of the CTSs (albeit effectively), but do so at the cost of shedding many other CTSs. Operators that use this strategy will score well in the CTS completion time measure, but will consequently score poorly for CTS shedding.

F.3.4   Trust

In the context of complex, human-machine systems, trust is defined as: "the extent to which a user is confident in and willing to act on the basis of the recommendations, actions, and decisions of an artificially intelligent decision aid" [7]. However, trust is not a simple uni-dimensional variable. It is possible to be correctly distrusting of a system (e.g., when it is unreliable), but also to be too trusting ('over-trusting' or complacent) or not trusting enough ('under-trusting' or sceptical).

Participant trust and acceptance of automation is determined from the outcome of a comparison process between the perceived reliability of the automated aid (i.e., trust in aid) and the perceived reliability of manual control (i.e., trust in self). Decision making quality will increase when the participant is able to compare the abilities of the CDSC with their own abilities. A subjective assessment based on one of the most recent and a comprehensive model of trust (i.e., model of Human-Computer Trust [2]) is recommended to measure the degree of participant trust in the CDSC. Overall trust in the CDSC is determined by cognition-based trust (i.e., trust relating to the participant's perception of the automation) and affect-based trust (i.e., trust relating to the participant's emotive response to automation). Three factors underpin cognition-based trust (i.e., perceived understandability, technical competence, and reliability [of the system]), and two factors underpin affect-based trust (i.e., faith [in the system] and personal attachment [to the system]). Each of these five factors has five sub-items as shown in Figure 20

1. **Perceived reliability**

   R1. The system always provides the advice I require to make my decision.

   R2. The system performs reliably.

   R3. The system responds the same way under the same conditions at different times.

   R4. can rely on the system to function properly.

   R5. The system analyzes problems consistently.

2. **Perceived technical competence**

   T1. The system uses appropriate methods to reach decisions.

   T2. The system has sound knowledge about this type of problem built into it.

   T3. The advice the system produces is as good as that which a highly competent person could produce.

   T4. The system correctly uses the information I enter.

   T5. The system makes use of all the knowledge and information available to it to produce its solution to the problem.

3. **Perceived understandability**

   U1. I know what will happen the next time I use the system because I understand how it behaves.

   U2. I understand how the system will assist me with decisions I have to make.

   U3. Although I may not know exactly how the system works, I know how to use it to make decisions about the problem.

   U4. It is easy to follow what the system does.

   U5. I recognize what I should do to get the advice I need from the system the next time I use it.

4. **Faith**

   F1. I believe advice from the system even when I don't know for certain that it is correct.

   F2. When I am uncertain about a decision I believe the system rather than myself.

   F3. If I am not sure about a decision, I have faith that the system will provide the best solution.

   F4. When the system gives unusual advice I am confident that the advice is correct.

   F5. Even if I have no reason to expect the system will be able to solve a difficult problem, I still feel certain that it will.

5. **Personal attachment**

   P1. I would feel a sense of loss if the system was unavailable and I could no longer use it.

   P2. I feel a sense of attachment to using the system.

   P3. I find the system suitable to my style of decision-making.

   P4. I like using the system for decision-making.

   P5. I have a personal preference for making decisions with the system.

Figure 20. Human-Computer Trust rating scale [7]

F.4   Experimental Plan

F.4.1   General

The following sections provide an overview of the proposed experimental approach to evaluate the Threat Evaluation (TE) and Combat Power Management (CPM) functional displays.

F.4.2 Experimental Design

A 2 (Scenario Complexity: low vs. high) x 2 (Decision Support System [DSS]: with vs. without) within-subjects design is proposed.

1. **Scenario Complexity:** Complexity refers to the type, number, tactics, location and timing of threats within the experimental scenario. The high complexity scenario should possess:

   a. An increased number of medium and high level threats requiring continual assessment and prioritization; and

   b. An increased number of targets requiring the application of combat power resources.

   c. Reduction in time to plan and apply combat power in response to an incoming target.

2. **With and Without Decision Support:** Refers to the presence of the functional displays to support the CPM decision making process. Specifically, the 'without DSS' condition would only entail a physical display representing the position of the threats (and friendly contacts).

This 2 x 2 design yields four experimental conditions. Given that both Decision Support and Scenario Complexity would be within-subjects factors, each operator should be tested under all levels of those factors.

In the high-complexity scenario, operators monitor and assess a larger number of threats as compared to the low-complexity scenario. Further, in the low-complexity scenario, operators engage one target at a time and in the high-complexity scenario operators engage multiple targets. The increased complexity in the scenario is intended to introduce additional demands on the operator with respect to the conduct of threat evaluation and application of combat power activities.

When operators are using the decision support system, they would use the TE and CPM functional views as well as the physical display to monitor contacts, threats, and targets. When operators are not using the decision support system, they would be limited to the physical display to monitor contacts, threats, and targets.

F.4.3 Experimental Hypotheses

Experimental hypotheses, in the form of predicted outcomes, are presented in relation to the independent variables and measures of performance discussed above for both the TE and CPM functional displays. The precise definition of critical task sequences depends on the scenarios and the capabilities of the prototype. Two generic tasks that require minimal interaction with the system and minimal programming of the INCOMMANDS prototype are proposed in this experimental plan for TE and for CPM. The TE tasks are to query the operators at pre-set intervals during the scenario to record the top three threats as well as having them identify pre-defined events (e.g., threat category jumps). The CPM tasks are to report which of the ship's combat power resources to employ to neutralize a target and to recommend when to launch a combat power resource to neutralize a target. Both accuracy and response time for these tasks should be measured.

F.4.3.1 Threat Evaluation

Scenario Complexity

With respect to the TE functional display, increasing scenario complexity will:

1. Decrease the operator's SA due to information overload. Operator SA should be assessed using the SART. Each operator would be asked to rate their SA for critical entities/events that were present or occurred in the most recently completed experimental scenario.

2. Increase the operator's workload due to more information being processed. Operator workload should be measured with the modified form of the NASA TLX discussed above. It will assess whether or not the scenario complexity manipulation is having its intended effect (i.e., workload ratings should increase as scenario complexity increases). The performance measures would need to be used to and the usability and utility questionnaires were used to assess it will highlight any OMI deficiencies. For example, if certain aspects of the OMI are difficult to use or interpret under certain conditions, then this will be reflected in the operator's rating of their frustration level.

3. Increase the time required by the operator to initiate and/or complete task-relevant performance due to information overload. Thus time related task-relevant performance would the operator's delays in reporting what their top three threats are and when a contact is promoted from a mid-level threat to a high-level threat.

4. Decrease the accuracy of the operator's task-relevant performance due to information overload. Task-relevant performance would be the number of errors operators make when reporting what their top three threats are and when a contact moves from a mid-level threat to a high-level threat.

Decision Support (with vs. without)

The presence of the TE functional display which includes, but is not limited to, a visual representation of prioritized and categorized threats as well as temporal information regarding the imminence of each threat should:

1. Increase the operator's SA since the system will assist the operator with anticipating such events as the emergence of threats as they migrate across threat categorization. Each operator should be asked to rate their SA (using the SART) for critical entities/events that were present or occurred in the most recently completed experimental scenario. Further, the provision for operator anticipation afforded by the threat visual representation will allow them to use 'down time' (e.g., during a lull in the scenario) to plan for potential future events (such as the requirement to report the top three threats). Thus, if these potential events do occur (especially if they occur when unforeseen events present themselves), then the anticipatory planning will serve to allow the operators to maintain a higher level of SA under these conditions.

2. Decrease the operator's workload since the system will be performing activities typically delegated to the operator. The modified NASA TLX should be used to assess operator

workload. It provides a method to assess whether or not the decision support system is having its intended effect (i.e., workload ratings should decrease with the presence of the TE functional display). Further, the provision for anticipatory planning afforded by the threat functional display will allow operators to plan for future events. If and when these 'future' events occur, operators will be better equipped to deal with them, especially if these events occur during a complex part of the scenario.

3. Decrease the time required by the operator to initiate and/or complete task-relevant performance because the TE functional display provides operators with greater, more detailed, and more quickly and easily interpretable information (e.g., temporal information) to identify and prioritize threats. In addition, the visual representation of temporal information relating to each entity's 'threat trajectory' over time should facilitate an operator's ability to accurately anticipate if (and when) a medium level threat will become a high level threat (i.e., a 'threat category jump').

4. Increase the accuracy of the operator's task-relevant performance because the TE functional display provides operators with greater, more detailed and more quickly and easily interpretable information (e.g., temporal information) to identify and prioritize threats.

F.4.3.2 Combat Power Management

It is anticipated that most (if not all) of the direct measures identified as part of the threat evaluation hypotheses will apply to the application of combat power function.

Scenario Complexity

With respect to the CPM functional view, increasing scenario complexity will:

1. Decrease the operator's SA due to information overload. This will make it more difficult for the operator to continually monitor the system-generated engagement plans. Operator SA should be assessed using the SART.

2. Increase the operator's workload due to the requirement for additional information to be processed. Operator workload should be measured with the modified NASA TLX. It will assess whether or not the scenario complexity manipulation is having its intended effect (i.e., workload ratings should increase as scenario complexity increases). Second, they will highlight any OMI deficiencies. For example, if certain aspects of the OMI are difficult to use or interpret under certain conditions, then this will be reflected in the operator's rating of their frustration level.

3. Increase the time required by the operator to initiate and/or complete task-relevant performance due to information overload. Time related task-relevant performance should be assessed by measuring operator delays when reporting which of the ship's combat power resources to employ to neutralize a target and when to launch a combat power resource to neutralize a target.

4. Decrease the accuracy of the operator's task-relevant performance due to information overload. Task-relevant performance should be assessed by measuring the number of errors

operators make when reporting which of the ship's combat power resources to employ to neutralize a threat.

Decision Support (with vs. without)

The presence of the CPM functional display which includes, but is not limited to, a visual representation of engagement plans as well as temporal information regarding the execution of atomic actions should:

1. Increase the operator's SA since they will be more visually aware of engagement plans and their execution. Each operator should be asked to rate their SA (using the SART) for critical entities/events that were present or occurred in the most recently completed experimental scenario. Further, the provision for operator anticipation afforded by the CPM functional view will allow them to use 'down time' (e.g., during a lull in the scenario) to plan for potential future events. Thus, if these potential events do occur (especially if they occur when unforeseen events present themselves), then the anticipatory planning will serve to allow the operators to maintain a higher level of SA under these conditions.

2. Decrease the operator's workload. The modified NASA TLX should be used to assess operator workload. It will assess whether or not the CPM functional display is having its intended effect (i.e., workload ratings should decrease with the CPM functional display).

3. Decrease the time required by the operator to initiate and/or complete task-relevant performance because the CPM functional display will provide operators with greater, more detailed, and more quickly and easily interpretable information (e.g., temporal information) to decide which of the ship's combat power resources to employ to neutralize a threat. Increase the accuracy of the operator's task-relevant performance because the CPM functional display will provide operators with greater, more detailed, and more quickly and easily interpretable information (e.g., temporal information) to identify which of the ship's combat resources to use and when to deploy the combat resource to ensure the threat is neutralized.

F.4.3.3 Scenario Complexity by Decision Support Interaction

It is assumed that the interaction between Scenario Complexity and Decision Support described below will not be differentially mediated by TE and CPM functional displays. As such, the anticipated results are expected to take the same form.

1. Operators using the DSS should be less impaired by high levels of scenario complexity than those not using the DSS due to the availability of temporal information. This predicted interaction is depicted in Figure 21. One explanation behind this claim is that the temporal information provided by the DSS would typically be maintained in the operator's working memory if this information was not made explicitly available to them. When using the DSS, the operator does not have to maintain this information in working memory, which therefore increases memory availability for other tasks.

2. Operators using DSS should be less impaired by high levels of scenario complexity than those not using the DSS when planning and applying combat power resources. Similar to the previous item, this outcome may be attributed to the CPM functional display representing

information typically retained in the operator's working memory. In the low scenario complexity condition, the performance difference between the 'with' vs. 'without' DSS conditions will not be as large.
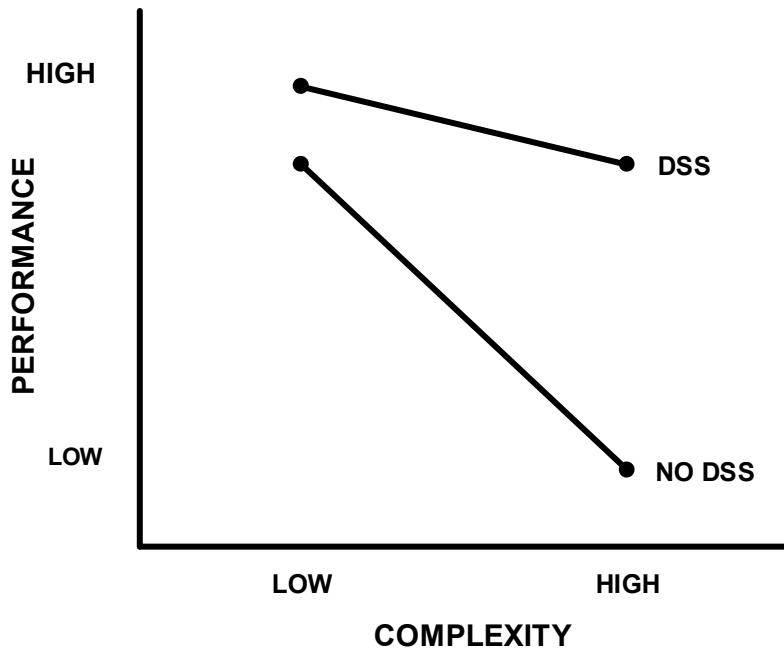

Figure 21: Anticipated Interaction Between Independent Variables

F.4.4   Participants

A minimum of eight active and qualified CF Naval operators between 18 and 60 years would be required for the above study. Operators should be either qualified as Operations Room Operators (ORO) or Sensor Weapons Controllers (SWC). The ORO and the SWC are the two primary Combat Power Management operators (i.e., threat evaluation, engageability assessment, combat power application) within the operations room of the HALIFAX Class frigate. The ORO is responsible for ensuring that the appropriate response is taken to counter any threat encountered by the ship. As such, the ORO evaluates the requirements for resources of each warfare area (air, surface, subsurface); resolving any conflicts that arise, to most effectively allocate those resources when conducting multi-warfare operations. The SWC manages two warfare areas (surface and air) including the assessment of threats, prioritization of targets, performance prediction of the above-water weapons and sensors as well as the planning and application of combat power.

All operators should have experience with the CCS-330 simulator. It is expected that participating operators will be recruited from Halifax, N.S. and will conduct the tasks while on duty; however, participation is voluntary.

F.4.5   Equipment and Facilities

The proposed experiment is designed to be carried out using the INCOMMANDS decision support system prototype. Video cameras will be required to record each trial.

The performance measures would need to be used to and the usability and utility questionnaires were used to assess Scenarios for stimulation of the individual trials during the experiment will be developed using STAGE Scenario.   The scenarios should have the following characteristics:

1. Be complete, coherent and allow key operator performance aspects to be measured (as defined a priori by the experimental team). For example, if the operator's SA is to be measured by asking them to identify which of two "medium" threats is most likely to next become a "high" threat (i.e., a "threat category jump"), then the scenario must include a situation where there are at least two "medium" threats that are strong "threat category jump" candidates.

2. Accommodate the independent manipulation of TE and CPM complexity as they are likely to be differentially affected. For example, the presence of a single threat is likely to produce low complexity for CPM but could produce high complexity for TE if there are many non-hostile tracks in addition to this single threat.

3. Allow each operator will be tested on both Decision Support conditions (with vs. without) and under both Scenario Complexities (low and high). Each individual operator will experience both levels of Scenario Complexity twice (once with the DSS and once without the DSS). If the same (low or high) complexity scenario is used twice, the operators' memory from their first experience with a scenario will influence their performance during their second exposure to that (same) scenario. In order to avoid this experimental confound, a second version of both the low and the high complexity scenarios must be created by taking the original scenario and rotating its mirror image. Track identification numbers for each contact should also be changed in order to further increase the disparity between the two scenario versions.

4. The two versions of both scenarios should be sufficiently different that any changes in operators' performance between the original scenario version compared to the rotated mirror image (i.e., modified) version cannot be attributed to the operators' memory for the ground truth from their first experience with that scenario. As such, any observable difference between the original and modified versions of the scenario can be more confidently attributed to differences between DSS conditions (with and without). Furthermore, these two scenario versions should be similar enough (e.g., same number and relative placement of unknown contacts) that both versions will induce similar workloads and can therefore be directly compared.

F.4.6   Counterbalancing

As discussed above, operators are to participate in all four experimental conditions. Since the operators will not have extensive experience with the INCOMMANDS system, it recommended that scenario complexity not be counterbalanced. That is, operators should always receive the low complexity scenarios first, once using the no DSS and once using the DSS. The high complexity

scenarios will then always occur after the low complexity scenarios. However, DSS presence/absence condition should be counterbalanced in that half of the operators receive the without DSS condition first followed by the with DSS condition. The order of the DSS presence/absence condition would be reversed for the other half of the operators. Additionally, scenario version should be counterbalanced across operators. Even if every attempt is made to equate the original version of a scenario with its modified version, there remains the possibility that they will not be perfectly matched. Thus, half of the operators should receive the original scenario version first and the modified version second. This order should be reversed for the other half of the operators. A minimum of eight operators are therefore required for a complete experimental counterbalance. The details of this counterbalancing scheme are shown in Table 1.

Table 1: Counterbalancing Details

Counter-balance		Experimental Trial			
		1	**2**	**3**	**4**
1	Scenario Complexity	LOW	LOW	HIGH	HIGH
	OMI Type	NO DSS	DSS	NO DSS	DSS
	Scenario Version	1	2	1	2
2	Scenario Complexity	LOW	LOW	HIGH	HIGH
	OMI Type	NO DSS	DSS	NO DSS	DSS
	Scenario Version	2	1	2	1
3	Scenario Complexity	LOW	LOW	HIGH	HIGH
	OMI Type	DSS	NO DSS	DSS	NO DSS
	Scenario Version	1	2	1	2
4	Scenario Complexity	LOW	LOW	HIGH	HIGH
	OMI Type	DSS	NO DSS	DSS	NO DSS
	Scenario Version	2	1	2	1

List of symbols/abbreviations/acronyms/initialisms

AWW	Above Water Warfare
C2	Command and Control
CCS	Command and Control System
CDS	Command Decision Support
CDSC	Command Decision Support Concept
CF	Canadian Forces
CFMWC	Canadian Forces Maritime Warfare Center
CO	Commanding Officer
COMDAT	Command Decision Aiding Technology
CONOPS	Concept of Operations
CP	Combat Power
CPM	Combat Power Management
CTS	Critical Task Sequence
DRDC	Defence Research and Development Canada
DSS	Decision Support System
EO	Electro-Optical
ESM	Electronic Support Measures
ESS	Electronic Support System
HCI	Human Computer Interaction
HCM	Halifax Class Modernization
HF	Human Factors
HREC	Human Research Ethics Committee
HSI	Human Systems Integration
INCOMMANDS	Innovative Naval Combat Management Decision Support
MOE	Measures of Effectiveness
MOP	Measures of Performance
OMI	Operator Machine Interface
ORO	Operations Room Officer
PS	Professional Services

ROE	Rules of Engagement
RMP	Recognized Maritime Picture
SA	Situational Awareness
SAM	Surface-to-Air Missile
SME	Subject Matter Expert
SOP	Standard Operating Procedure
SOW	Statement of Work
SSM	Surface-to-Surface Missile
SWC	Sensor Weapons Controller
TAM	Technology Acceptance Model
TDP	Technology Demonstration Project
TE	Threat Evaluation
TLX	Task Load Index

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(U) The Innovative Naval COMbat MANagement Decision Support (INCOMMANDS) Technology Demonstration Project (TDP) attempts to improve the performance of Threat Evaluation (TE) and Combat Power Management (CPM) functions in response to multiple threats and impediments introduced by the littoral environment. Specifically, the purpose of the INCOMMANDS TDP is to develop and demonstrate advanced Above Water Warfare (AWW) command decision support concepts for the command team of the Halifax Class Frigate in order to improve the overall TE and CPM decision–making effectiveness. This report presents preliminary validation results stemming from a Heuristic Evaluation by a Human Factors analyst and Usability and Utility Testing with Naval operators of the INCOMMANDS Command Decision Support Capability (CDSC) prototype. The results of the usability and utility evaluation suggest that the concepts presented in the INCOMMANDS CDSC would improve task performance, increase situation awareness, and decrease operator workload. Further analysis and evaluation efforts are required to substantiate this finding.

(U) Le projet de démonstration technologique (PDT) INCOMMANDS (Innovative Naval COMbat MANagement Decision Support, en anglais) vise à améliorer l'efficacité des fonctions d'évaluation des menaces et de gestion de la puissance de combat dans le cadre de scénarios de menaces multiples et d'obstacles introduits par le milieu littoral. Plus précisément, le PDT INCOMMANDS vise à élaborer et à démontrer des concepts avancés d'aide aux prises de décisions de commandement en situation de guerre aérienne et de surface pour l'équipe de commandement des frégates de classe Halifax afin d'améliorer ses capacités d'évaluation de la menace et de gestion de la puissance de combat. Le présent rapport expose les résultats de validation préliminaire d'une évaluation heuristique par un analyste des facteurs humains et d'une série d'essais de convivialité et de fonctionnalité effectués avec des opérateurs navals du prototype d'aide à la décision de commandement développé dans le cadre du projet INCOMMANDS. Les résultats de cette évaluation suggèrent que les concepts mis de l'avant par le PDT INCOMMANDS permettraient d'améliorer l'accomplissement des tâches, d'augmenter la connaissance de la situation et de réduire la charge de travail des opérateurs. D'autres analyses et évaluations seront nécessaires pour confirmer ces constatations.

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(U) INCOMMANDS TDP, Threat Evaluation and Combat Power Management, decision support, operator–machine interface, human factors evaluation; heuristic analysis; usability; utility

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